

Security Handshake Pitfalls

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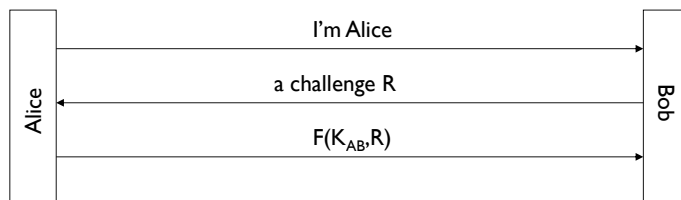
Cryptographic Authentication

- Password authentication is subject to eavesdropping
- Alternative: Cryptographic challenge-response
 - Symmetric key
 - Public key

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Symmetric Key Challenge-Response

An example protocol:

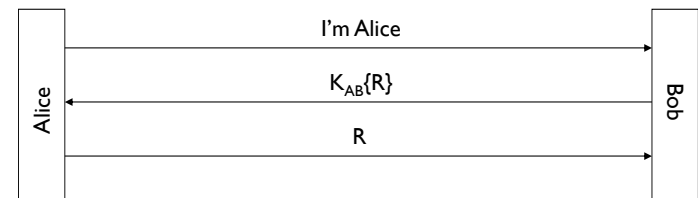


- Authentication not mutual (login only)
- Subject to connection hijacking (login only)
- Subject to off-line password guessing (if K is derived from password)
- Bob's database has keys in the clear

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Symmetric Key Challenge-Response

An alternative protocol:

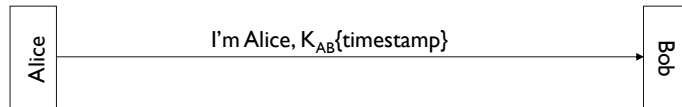


- Requires reversible cryptography
- Subject to dictionary attack, **without eavesdropping**, if R is recognizable
- Can be used for mutual authentication if R is recognizable and has limited lifetime

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Symmetric Key Challenge-Response

A one-message protocol:

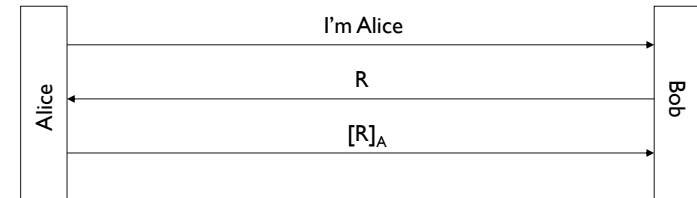


- Easy integration into password-sending systems
 - More efficient: Single message, stateless
 - Care needed against replays: timeout needed
 - Care needed if key is common across servers
 - Clock has to be protected as well
- Alternatively, with a hash function, send,
I'm Alice, timestamp, $H(K_{AB}, \text{timestamp})$

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Public Key Challenge-Response

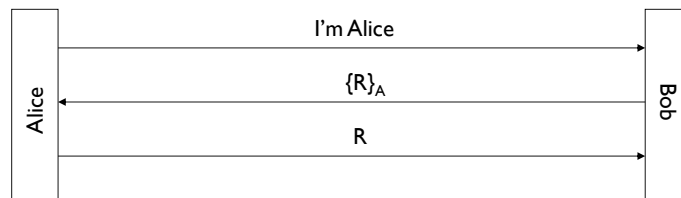
By signature:



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Public Key Challenge-Response

By decryption:

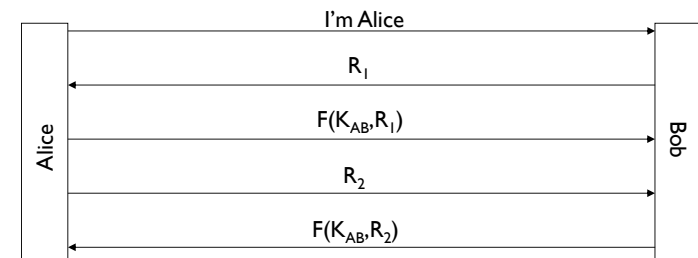


- Problem: Bob (or Trudy) can get Alice to sign/decrypt any text he chooses.
- Solutions:
 - Never use the same key for different purposes (e.g., for login and signature)
 - Use formatted challenges

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Mutual Authentication

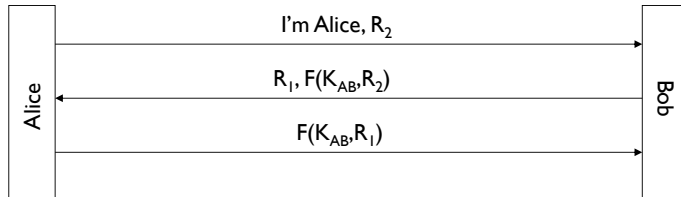
An example protocol:



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Mutual Authentication with Few Messages

Number of messages for mutual authentication can be reduced:



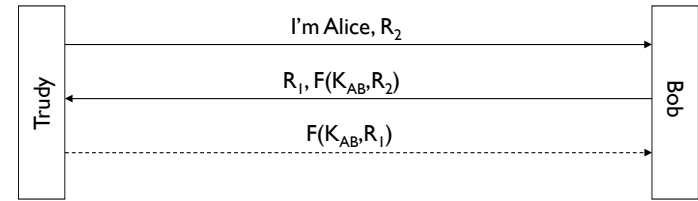
However, this protocol is vulnerable to

- Reflection attack
- Dictionary attack :Trudy can do dictionary attack against K_{AB} acting as Alice, without eavesdropping.

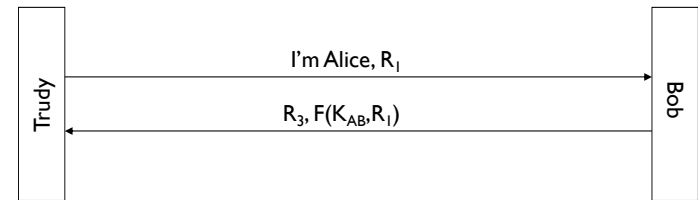
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Reflection Attack:

Original session:



Decoy session:



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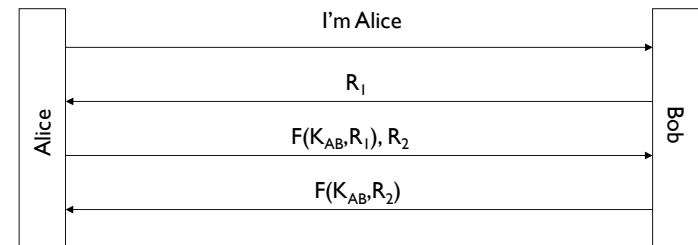
Results from Reflection Attack

- Solutions:
 - Different keys for Alice and Bob
 - Formatted challenges, different for Alice and Bob
- Principle:
 - Initiator should be the first to prove its identity

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A Modified Mutual Authentication Scheme

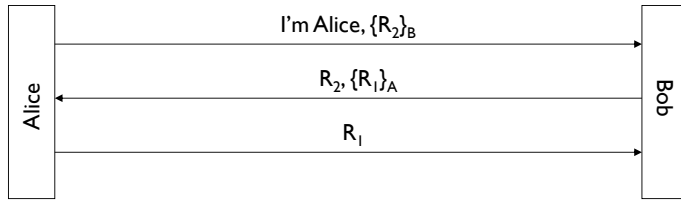
- Solution against both problems:



- Dictionary attack is still possible if Trudy can impersonate Bob.

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Mutual Authentication with Public Keys



- Problem: How can the public/private keys be remembered by ordinary users?
 - Possibly, they can be retrieved from a server with password based authentication & encryption.

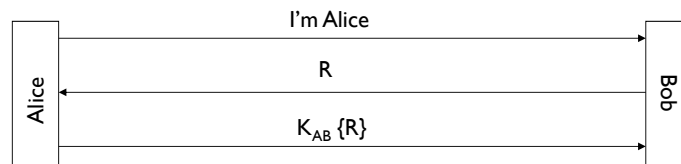
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Session Key Establishment

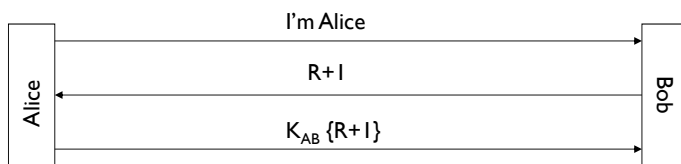
- A **session key** is needed for integrity protection and encryption in a communication session. It must be
 - different for each session
 - unguessable by an eavesdropper
 - not $K_{AB}\{x\}$ for some x predictable/extractable by an attacker
- Session keys can be established by using
 - Symmetric encryption
 - Public key encryption

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Session Key Establishment with Symmetric Encryption



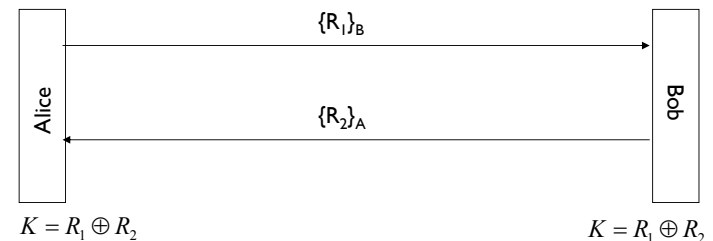
- Do not use $K_{AB}\{R\}$ or $K_{AB}\{R+I\}$
 - Take $(K_{AB}+I)\{R\}$ as the session key.



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Session Key Establishment with Public Key Cryptosystem

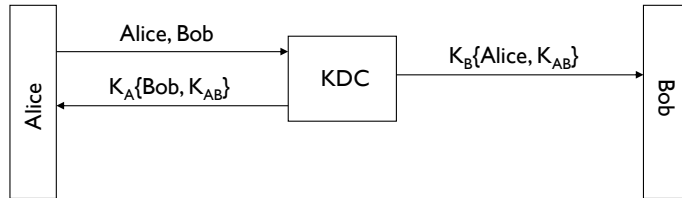
- An alternative is to use Diffie-Helman key exchange algorithm.
- Another alternative with PKC, send additional random nonces $\{R\}_A$, $\{R\}_B$ and use them to derive a session key.



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Key Establishment and Authentication with Key Distribution Center (KDC)

A simple protocol:

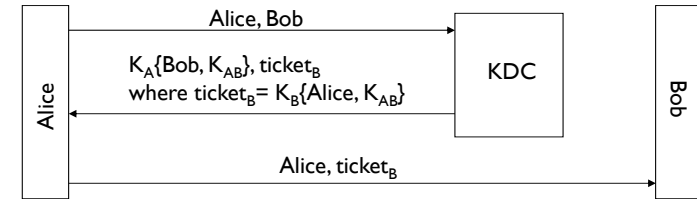


- Problem:
 - Potential delayed key delivery to Bob. (besides others)

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Key Establishment and Authentication with KDC

• Another simple protocol:



- Problems:
 - No freshness guarantee for K_{AB}
 - Alice & Bob need to authenticate

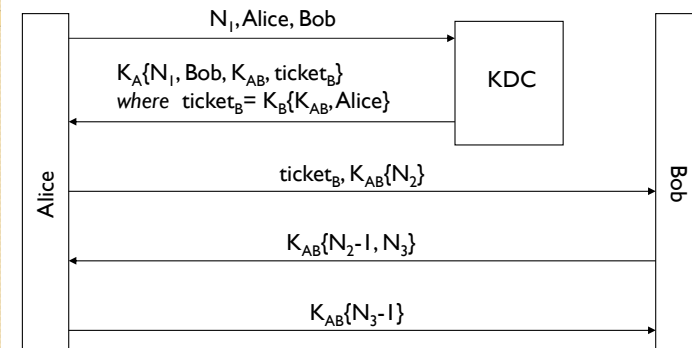
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Nonces

- Nonce: Something created for one particular occasion
- Nonce types:
 - Random numbers
 - Timestamps
 - Sequence numbers
- Random nonces needed for unpredictability
- Obtaining random nonces from timestamps: encryption with a secret key.

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Needham-Schroeder Protocol



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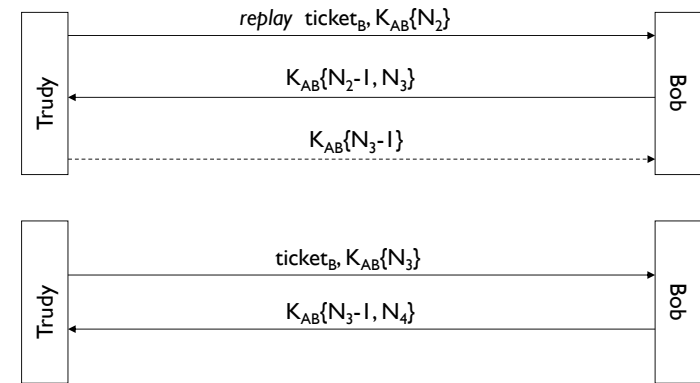
Needham-Schroeder Protocol

- Ticket is double-encrypted. (unnecessary)
- N_1 : for authenticating KDC & freshness of K_{AB} .
- N_2, N_3 : for key confirmation, mutual authentication
- Why are the challenges N_2, N_3 encrypted?
- Problem: Bob doesn't have freshness guarantee for K_{AB} (i.e., can't detect replays).

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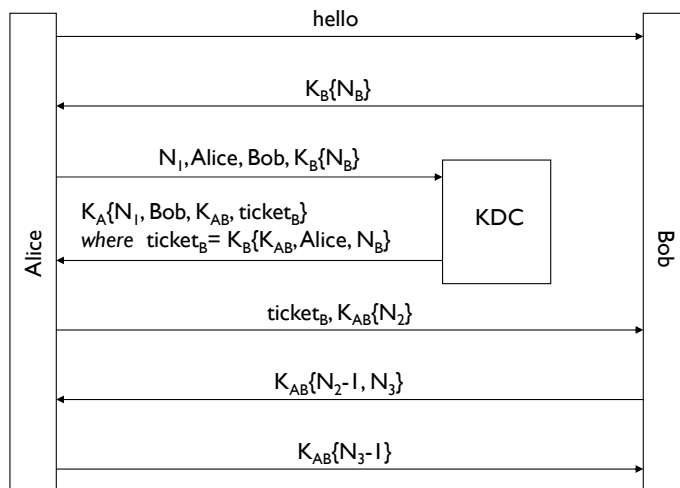
Replaying Tickets

- Messages should be integrity protected. Otherwise, cut-and-paste reflection attacks possible:



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Expanded Needham-Schroeder Protocol



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Protocol Performance Comparison

- Computational Complexity: (to minimize CPU time, power consumption)
 - Number of private-key operations
 - “ “ public-key “
 - “ “ bytes encrypted with secret key
 - “ “ bytes hashed
- Communication Complexity:
 - Number of message rounds
 - Bandwidth consumption

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