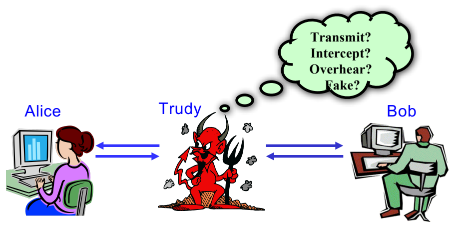
CS458/CS558 Introduction to Computer Security

Chapter 13.2 Authentication Protocols

Authentication Protocols

- Used to convince parties of each other's identity and to exchange session keys



Authentication Protocols

- Published protocols are often found to have flaws and need to be modified
- Key issues are
  - Confidentiality
    - To prevent masquerade and to prevent compromise of session keys, essential identification and session key information must be communicated in encrypted form.
  - Timeliness – to prevent replay attacks

Replay Attacks

- A valid signed message is copied and later resent
  - Simple replay: the opponent simply copies a message and replays it later
  - Repetition that can be logged: an opponent can replay a timestamped message within the valid time window
  - Repetition that cannot be detected: may arise because the original message could have been suppressed and thus did not arrive at its destination; only the replay message arrives.
  - Backward replay without modification: a replay back to the sender
    - When using symmetric encryption, the sender cannot easily recognize the difference between messages sent and messages received.

Replay Attacks

- Countermeasures
  - Attach a sequence number to each message used in an authentication exchange
    - Generally impractical – requires each party to keep track of the last sequence number for each claimant it has dealt with
  - Timestamps: party A accepts a message as fresh only if the message contains a timestamp that, in A's judgment, is close enough to A's knowledge of current time.
    - Needs synchronized clocks

Replay Attacks (Cont.)

- Countermeasures
  - Nonce: a random number that illustrate the freshness of a session.
    - Party A sends B a nonce and requires that the subsequent response received from B contains the correct nonce value.

Using Symmetric Encryption

- As discussed previously can use a two-level hierarchy of keys
- Usually with a trusted Key Distribution Center (KDC)
  - Each party shares own master key with KDC
  - KDC generates session keys used for connections between parties
  - Master keys used to distribute these to them

Needham-Schroeder Symmetric Key Protocol

- Original third-party key distribution protocol
- For session between A B mediated by KDC
- Protocol:

1. A->KDC: $ID_A \| ID_B \| N_1$

2. KDC -> A: $E_{Ka}[Ks \| ID_B \| N_1 \| E_{Kb}[Ks\|ID_A]]$

3. A -> B: $E_{Kb}[Ks\|ID_A]$

4. B -> A: $E_{Ks}[N_2]$

5. A -> B: $E_{Ks}[f(N_2)]$

Attack: Needham-Schroeder Protocol

3. A -> B: $E_{Kb}[Ks\|ID_A]$

4. B -> A: $E_{Ks}[N_2]$

5. A -> B: $E_{Ks}[f(N_2)]$

- Suppose that an attacker X has been able to compromise an old session key.

Attack: Needham-Schroeder Protocol

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- Suppose that an attacker X has been able to compromise an old session key.
- X can impersonate A and trick B into using the old key by simply replaying step 3.
- Unless B remembers indefinitely all previous session keys used with A, B will be unable to determine that this is a replay.
- X then intercepts the step 4 and sends bogus messages to B that appear to B to come from A using an authenticated session key

Solution: Needham-Schroeder Protocol

- Use a timestamp T that assures A and B that the session key has only just been generated.
- Revised protocol:

1. A->KDC: $ID_A \| ID_B \| N_1$

2. KDC -> A: $E_{Ka}[Ks \| ID_B \| N_1 \| E_{Kb}[Ks\|ID_A\|T]]$

3. A -> B: $E_{Kb}[Ks\|ID_A\|T]$

4. B -> A: $E_{Ks}[N_2]$

5. A -> B: $E_{Ks}[f(N_2)]$

Timestamp

- Principals can verify the timeliness by checking:

  $$|Clock - T| < \Delta t_1 + \Delta t_2$$

  - Δt_1: The estimated normal discrepancy between the KDC's clock and the local clock (principals' clock)
  - Δt_2: The expected network delay time
- Need to synchronize clock

Suppress-Replay Attacks

- Suppress-replay attacks: when the sender's clock is ahead of the receiver's clock, the opponent can intercept a message from the sender and replay it later when the timestamp in the message becomes current at the receiver's site.
  - Replaying a message to purchase oil stocks one day later could result in a purchase when the stock price had already changed significantly.

Suppress-Replay Attacks

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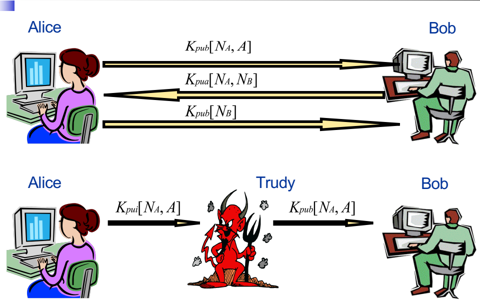
  - Replaying a message to purchase oil stocks one day later could result in a purchase when the stock price had already changed significantly.
- Countermeasure:
  - Enforce the requirement that parties regularly check their clocks against the KDC's clock.
  - Rely on handshaking protocols using nonces.

Using Public-Key Encryption

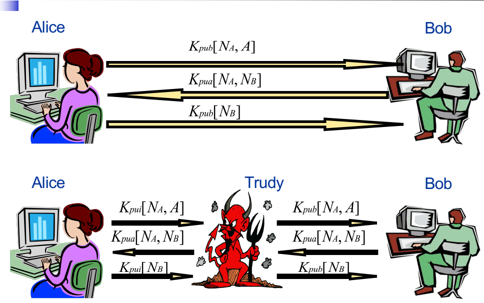
- Have a range of approaches based on the use of public-key encryption
- Need to ensure have correct public keys for other parties
- Various protocols exist using timestamps or nonces

Needham-Schroeder Public Key Protocol



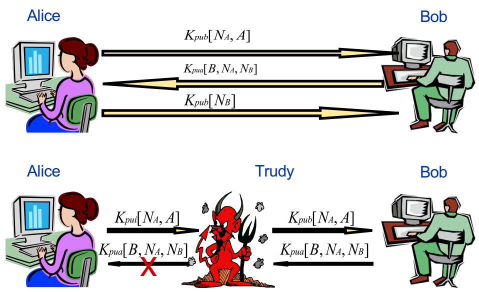
[Lowe, 1995]

Needham-Schroeder Public Key Protocol



[Lowe, 1995]

Needham-Schroeder-Lowe Public Key Protocol



One-Way Authentication

- Required when sender and receiver are not in communications at same time (eg. email)
- Have header in clear so can be delivered by email system
- May want contents of body protected & sender authenticated

Using Symmetric Encryption

- Can refine use of KDC but cannot have exchange of nonces:

1. A->KDC: $ID_A \| ID_B \| N_1$
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3. A -> B: $E_{Kb}[Ks \| ID_A] \| E_{Ks}[M]$

Using Symmetric Encryption

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- Guarantees that only the intended recipient of a message will be able to read it.
- Does not protect against replays
  - Could rely on timestamp in message, though email delays make this problematic

Assignment 4

- Due: April 16th (Monday)
- Done individually or by a group of two students
- Two choices: rootkit or PGP (choose ONE of them)

Assignment 4: Choice I

- choice I: Rootkit
- Find and download a windows rootkit that enables the attacker to hide files or processes, and demonstrate how to do it.
- You will need to install a virtual machine (e.g. virtualbox) and execute the rootkit inside the virtual machine.
- Demo: April 16th at G25 (or during Nikhil's office hours before April 16th)

Assignment 4: Choice II

- choice II: PGP
- Find PGP software that supports confidentiality and digital signature, and show how to use PGP to provide confidentiality and digital signature.
- You can choose any email client and any PGP software.
- Demo: April 16th at G25 (or during Nikhil's office hours before April 16th)