Introduction to Cryptography CS 355

Lecture 31

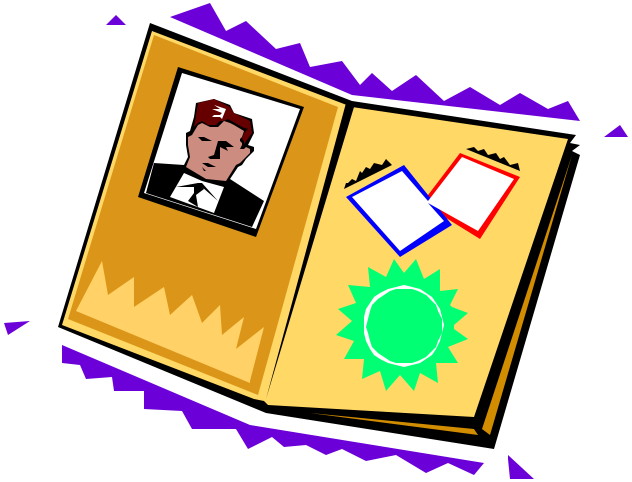
Identification Schemes

Lecture Outline

- Identification schemes
  - passwords
  - one-time passwords
  - challenge-response
  - zero knowledge proof protocols

Authentication

- **Data source authentication (message authentication)**: a message is generated by a specific party.
- **Entity authentication (identification)**: the process whereby one party (the verifier) is assured of the identity of a second party (prover) involved in a protocol



Requirements of Identification Protocols

- Requirements of identification protocols
  - for honest prover A and verifier B, A is able to convince B
  - no other party can convince B
  - in particular, B cannot convince C that it is A
- Kinds of attackers
  - passive and replay
  - active, man in the middle
  - the verifier

Properties of Identification Protocols

- Computational efficiency
- Communication efficiency
- Security requirement of communication channels
- Trust in verifier
- Storage of secrets
- Involvement of a third party
- Nature of trust in the third party
- Nature of security: provable security

Authentication Using Fixed Passwords

- Prover authenticates to a verifier using a password.
- Require secure communication channels
- Total trust in verifier
- Passwords must be kept in encrypted form or just digests of passwords are kept.
- Attacks:
  – Replay of fixed passwords
  – Online exhaustive password search
  – Offline password-guessing and dictionary attacks

Unix crypt Algorithm

- Used to store Unix passwords
- Information stored is /etc/passwd is:
  - Iterated DES encryption of 0 (64 bits), using the password as key
  - 12 bit random salt taken from the system clock time at the password creation
- Unix use salting to change the expansion function in DES
  - to make dictionary attacks more difficult.
  - also to prevent use of off-the-shelf DES chips

One-time passwords

- Each password is used only once
  - Defend against passive adversaries who eavesdrop and later attempt to impersonate
- Variations
  - shared lists of one-time passwords
    - challenge-response table
  - sequentially updated one-time passwords
  - one-time password sequences based on a one-way function

Lamport's One-Time Password

Stronger authentication than password-based

- One-time setup:
  - A selects a value w, a hash function H(), and an integer t, computes $w_0 = H^t(w)$ and sends w_0 to B
  - B stores w_0
- Protocol: to identify to B for the i^{th} time, $1 \leq i \leq t$
  - A sends to B: A, i, $w_i = H^{t-i}(w)$
  - B checks $i = i_A$, $H(w_i) = w_{i-1}$
  - if both holds, $i_A = i_A+1$

Challenge-Response Protocols

- Goal: one entity authenticates to other entity proving the knowledge of a secret, ‘challenge’
- Time-variant parameters used to prevent replay, interleaving attacks, provide uniqueness and timeliness : nounce (used only once)
- Three types:
  - Random numbers
  - Sequences
  - Timestamp

Challenge-Response Protocols

- **Random numbers**:
  - pseudo-random numbers that are unpredictable to an adversary;
  - need strong pseudo-random strings;
  - must maintain state;
- **Sequences**:
  - serial number or counters;
  - long-term state information must be maintained by both parties+ synchronization
- **Timestamp**:
  - provides timeliness and detects forced delays;
  - requires synchronized clocks.

Challenge-response based on symmetric-key encryption

- Unilateral authentication, timestamp-based
  - A to B: $E_K(t_A, B)$
- Unilateral authentication, random-number-based
  - B to A: r_B
  - A to B: $E_K(r_B, B)$
- Mutual authentication, using random numbers
  - B to A: r_B
  - A to B: $E_K(r_A, r_B, B)$
  - B to A: $E_K(r_B, r_A)$

Challenge-Response Protocols Using Digital Signatures

- unilateral authentication with timestamp

  $A \rightarrow B$: $cert_A$, t_A, B, $S_A(t_A, B)$

- unilateral authentication with random numbers

  $A \leftarrow B$: r_B

  $A \rightarrow B$: $cert_A$, r_A, B, $S_A(r_A, r_B, B)$

- mutual authentication with random numbers

  $A \leftarrow B$: r_B

  $A \rightarrow B$: $cert_A$, r_A, B, $S_A(r_A, r_B, B)$

  $A \leftarrow B$: $cert_B$, A, $S_B(r_B, r_A, A)$

Zero-Knowledge Protocols

- **Motivation:**
  - Password-based protocols: when Alice authenticates to a server, she gives her password, so the server can then impersonate her.
  - Challenge-response improves on this, but still reveals partial information.
- **Zero-knowledge protocols**: allows a prover to prove that is posses a secret without revealing any information of use to the verifier.

Fiat-Shamir ID protocol (ZK Proof of knowledge of square root modulo n)

- System parameter: $n=pq$,
- Public identity: v $\quad v = s^2 \bmod n$
- Private authenticator: s
- Protocol (repeat t times)

1. A: picks random r in Z_n^*, sends $x=r^2 \bmod n$ to B
2. B checks $x \neq 0$ and sends random c in {0,1} to A
3. A sends y to B, where If $c=0$, $y=r$, else $y=rs \bmod n$.
4. B accept if $y^2 \equiv xv^c \bmod n$

Observations on the Protocol

- Multiple rounds
- Each round consists of 3 steps
  - commit
  - challenge
  - respond
- If challenge can be predicted, then cheating is possible.
  - cannot convince a third party (even if the party is online)
- If respond to more than one challenge with one commit, then the secret is revealed.

Coming Attractions …

- More on Zero Knowledge Proof protocols