COMP 3704 Computer Security

Christian Grothoff
christian@grothoff.org

http://grothoff.org/christian/

Zero-Knowledge Proofs

1. Peggy wants to prove to Victor that she has a particular piece of information, but without giving Victor the information.
2. Peggy transforms NP-complete problem P into equivalent NP-complete problem V using secret, random transformation T
3. Given V, Victor can choose to see either solution to V or transformation T.
4. Peggy has 50% chance of cheating, so iterate n times!

Example: Graph Isomorphism

Two graphs are isomorphic if they are identical modulo renaming of points; determining GI is NP-complete.

1. Peggy wants to provide zero-knowledge proof of her knowing the isomorphism between G_1 and G_2.
2. Peggy randomly permutes G_1 to produce H and now has isomorphisms $G_1 \equiv H \equiv G_2$. H is given to Victor.
3. Victor requests proof that either $G_1 \equiv H$ or $H \equiv G_2$.
4. Peggy provides the requested isomorphism, which Victor verifies.

Noninteractive Zero-Knowledge Proofs

- Peggy does not want to repeat the interactive proof to everyone.
- Instead of having Victor choose at random, use hash-function over information provided to Victor as PRNG.
- Use combined n transformations of the problem as input to PRNG.

Blind Signatures

1. Alice sends Bob $M \cdot R_A$ where R_A is called a **blinding factor**
2. Bob sends back $S_{B_{priv}}(M \cdot R_A)$
3. Alice divides out the blinding factor, obtaining $S_{B_{priv}}(M)$

Naturally, this only works if the signature function allows Alice to divide the blinding factor.

Half-Blind Signatures

1. Alice sends Bob n blinded documents.
2. Bob requests the blinding factors for $n-1$ random documents.
3. Alice provides those blinding factors.
4. Bob unblinds and checks that the $n-1$ documents would have been acceptable and blindly signs the remaining document.
5. Alice can get Bob to sign anything with probability $1:n$.

Identity-based Public-Key Cryptography

- Idea: generate public-private key pairs based on the identity of the users
- Practical variant: define your identity to be your public key
- Issue: anyone can create any number of identities

Oblivious Transfer

1. Alice generates two public-key pairs, sends the public keys to Bob.
2. Bob sends Alice $E(K)$ using one of the public keys.
3. Alice decrypts with both of her keys, obtaining K and K'.
4. Alice sends Bob $E_K(M_1), E_{K'}(M_2)$ or $E_{K'}(M_1), E_K(M_2)$ (but she does not know which).
5. Bob tries to decrypt both, gets either M_1 or M_2.

Oblivious Transfer: Verification

- If Bob wants to verify that Alice did not cheat, he needs to receive Alice's public keys at some point (at that time he will learn both messages).

Simultaneous Contract Signing (1/2)

1. Alice and Bob each generate $2n$ symmetric keys and n pairs of messages L_i and R_i representing the left and right halfs of the i-th signature.

2. Alice and Bob exchange the encrypted signature pairs.

3. Alice and Bob use oblivious transfer to share n of the $2n$ keys (one for each pair).

4. Alice and Bob verify that the L_i's and R_i's that they can now decrypt are valid.

Simultaneous Contract Signing (2/2)

5. Alice sends Bob the first bits of her $2n$ symmetric keys.
6. Bob sends Alice the first bits of his $2n$ symmetric keys.
7. They iterate the previous steps until all bits of all keys have been transferred.
8. They decrypt the remaining halves of the message pairs and obtain a valid signature.
9. They exchange the private keys used during oblivious transfer and verify that the other did not cheat.

Questions

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Problem

Why is the protocol described in the textbook in Section 5.8, pages 122-123 broken?