CS 519

Cryptography and Network Security

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Midterm Exam

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Question 1. (*40 pts.*) Answer briefly each of the following questions:

a. Why may a slow key schedule be desirable for a cipher? (e.g. Blowfish) Explain briefly.

b. In which of the ECB, CBC, OFB, CFB, and CTR modes of operation, is *encryption* parallelizable?

c. Is a fixed or a random IV preferable in a CBC-MAC computation? Why?

d. What is the role of the "compression function" in the structure of a hash function? (I.e., describe the operation of a hash function according to the compression function.)

e. As MACs can be produced from hash functions, consider producing a hash function from CBC-MAC, where the CBC checksum of a message is computed using a fixed key and IV. Would this hash function be secure? Why/why not?

f. Is a fixed or random padding used in the PKCS for RSA signature? Why?

g. Can the ElGamal encryption system be used as a signature algorithm in a straightforward manner—using the private key operation for signing and the public key operation for verification? Why/why not?

h. A dishonest dealer might distribute "bad" shares for a Shamir threshold scheme, i.e., shares for which different t-subsets determine different keys. Given all n shares, we could test the consistency of the shares by computing the key for every one of the $\binom{n}{t}$ t-subsets of participants, and verifying that the same key is computed in each case. Describe a more efficient method for testing the consistency of the shares.

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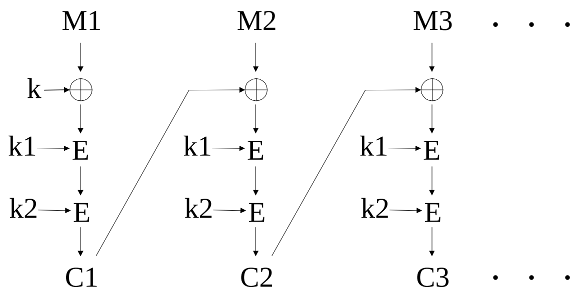
Question 2. (*20 pts.*) Consider the following mode of encryption with three keys k, $k1$, $k2$, where k is of the length of the block size and $k1$ and $k2$ are of the length of the key size (denoted by ℓ) of the block cipher E. (E.g., for DES, k would be 64 bits, and $k1$ and $k2$ would be 56 bits each.)



a. Describe the decryption operation for this mode of encryption.

b. Describe a known-plaintext attack with a relatively small number of input blocks (e.g., with 20 or 30 blocks) where the attacker can discover the full key $(k, k1, k2)$ with approximately $2 \cdot 2^{\ell}$ runs of the encryption/decryption algorithm. (You can assume as much memory as you need for the attack.)

c. Comment on the security of this mode of encryption as a potential way of strengthening DES with an increased key size.

Question 3. (*20 pts.*) Consider a variant of the ElGamal signature scheme where $p, g, \alpha, \beta, k, r$ are as in the original scheme as described in class and

$$s = (r\alpha + k)m^{-1} \bmod (p-1),$$

where you can assume that m is always relatively prime to $p-1$.

a) What would the signature verification formula be for the modified scheme? (Put your answer in a frame.)

b) Show that this ElGamal variant is insecure. (Hint: Show that attacker Eve who has observed the signature of a message m can obtain the signature of any message she likes.)

Question 4. (*20 pts.*) Alice computes her RSA signatures in an optimized way by first computing $y_p = x^d \bmod p$, $y_q = x^d \bmod q$, and then obtaining $y = x^d \bmod n$ by the Chinese Remainder Theorem. During the signature of a message, while y_p was being computed, a glitch at Alice's computer caused it to produce a wrong value $\tilde{y_p}$ different from y_p. Then the computation of y_q proceeded without any errors. At the end, a wrong signature $\tilde{y}$ was obtained from $\tilde{y_p}$ and y_q.

a) Show that any person who observes the message x with the wrong signature $\tilde{y}$ can factor Alice's modulus n. (Hint: Use the fact that $\tilde{y}^e \equiv x \pmod{q}$.)

b) Suggest some method by which Alice can defend against this danger.

Good luck!