Midterm: Part I

Note

This is a closed-book exam. Part I contains five problems, each accounting for 10 points.

Problems

1. (a) What are the four general services, aside from *access control* and *availability*, that encompass the various functions required of an information security facility? Please briefly explain.

   (b) Name and describe two types of passive attack and three types of active attack.

2. Consider the AES algorithm, where the irreducible polynomial modulus is $x^8+x^4+x^3+x+1$.

   (a) How can the multiplication of two bytes be implemented in terms of shift and bitwise XOR operations? What is the result of (1011 1010) $\cdot$ (0000 0110)? Show the steps of your calculation.

   (b) What is the value of $(0101\ 1011)^{-1}$? Show the steps of your calculation.

3. (a) How does three-key triple DES achieve backward compatibility with DES? Please describe all alternatives.

   (b) What are the advantages of the Counter (CTR) Mode of Operation for symmetric block ciphers? Please try to be as comprehensive as possible.

4. What is a hierarchical key control (for key distribution)? How does it operate? What are its advantages?

5. Consider the following communication protocol: each node N in the network has been assigned a unique secret key K_n. This key is used to secure communication between the node and a trusted server, which stores all the keys. User A, wishing to send a secret message M to user B, initiates the following protocol:

   (a) A generates a random number R and sends to the server (1) his name A, (2) destination B, and (3) $E(K_a, R)$.

   (b) The server responds by sending $E(K_b, R)$ to A.

   (c) A sends $E(R, M)$ together with $E(K_b, R)$ to B.

(d) B knows K_b, thus decrypts $E(K_b, R)$ to get R and will subsequently use R to decrypt $E(R, M)$ to get M.

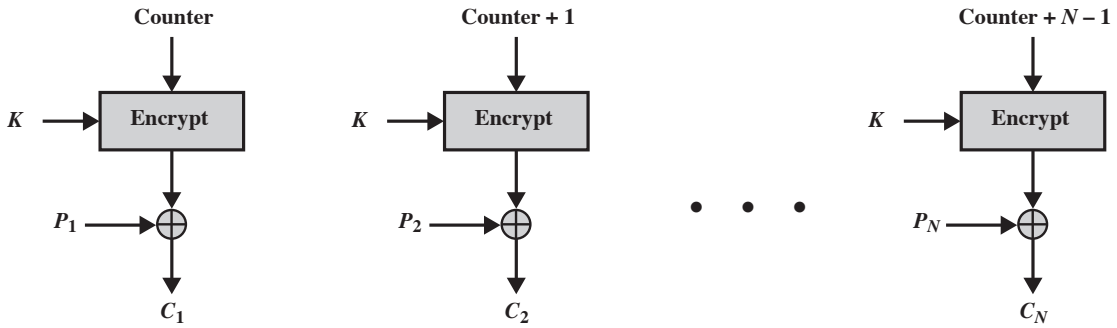
An intruder with legal access to one of the network nodes may be able to obtain the plain text of any secret message that has been transmitted between two other nodes. Please describe such an attack.

Appendix

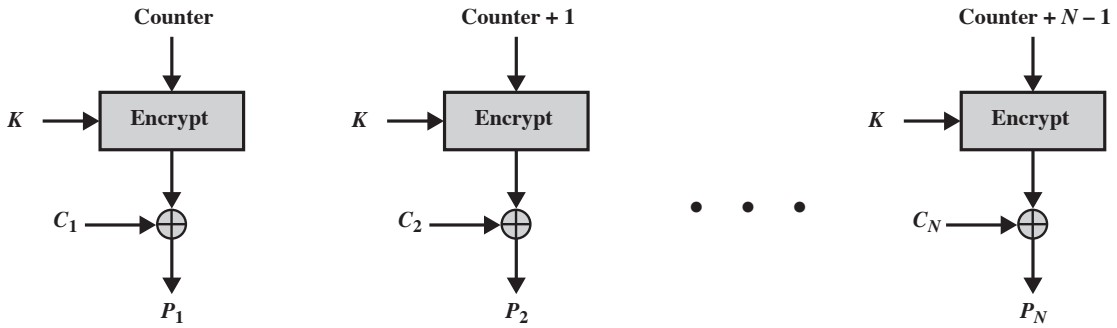
- The extended Euclid's algorithm for polynomials is as follows.

$EXTENDED\ EUCLID(m(x), b(x))$:
1. $[A_1(x), A_2(x), A_3(x)] \leftarrow [1, 0, m(x)]; [B_1(x), B_2(x), B_3(x)] \leftarrow [0, 1, b(x)]$
2. if $B_3(x) = 0$ then return $A_3(x) = \gcd(m(x), b(x))$; no inverse
3. if $B_3(x) = 1$ then return $A_3(x) = \gcd(m(x), b(x)); B_2(x) = b^{-1}(x) \pmod{m(x)}$
4. $Q(x) =$ the quotient of $A_3(x)/B_3(x)$
5. $[T_1(x), T_2(x), T_3(x)] \leftarrow [A_1(x) - Q(x)B_1(x), A_2(x) - Q(x)B_2(x), A_3(x) - Q(x)B_3(x)]$
6. $[A_1(x), A_2(x), A_3(x)] \leftarrow [B_1(x), B_2(x), B_3(x)]$
7. $[B_1(x), B_2(x), B_3(x)] \leftarrow [T_1(x), T_2(x), T_3(x)]$
8. goto 2

- The Counter (CTR) Mode of Operation in picture:



(a) Encryption



(b) Decryption