Weaver
Fall 2019

CS 161
Computer Security

Discussion 3

Cryptography I

Question 1 ***Block Cipher Potpourri*** **(20 min)**

(a) Are block ciphers IND-CPA?

(b) What are good possible sources of entropy for key generation for a block cipher?

- The computer's clock time (assumed in seconds)
- The Parent Process ID $\oplus$ my Process ID $\oplus$ time
- Hardware noise generator
- Hardware noise generator $\oplus$ time
- 101010101... $\oplus$ Hardware noise generator

(c) Why does a block cipher need to be a permutation?

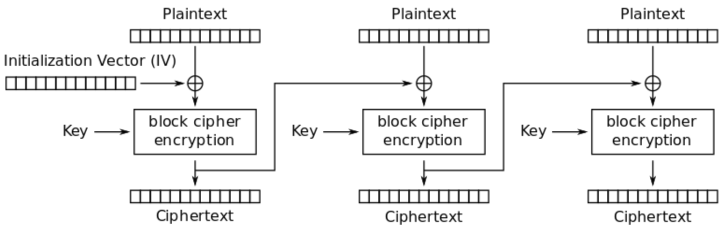
Question 2 *PRNGs and stream ciphers* (20 min)

(a) Pretend I have given you a pseudo-random number generator R. R is a function that takes a 128-bit seed s, an integer n, and an integer m, and outputs the n^{th} (inclusive) through m^{th} (exclusive) pseudo-random bits produced by the generator when it is seeded with seed s. Use R to make a secure symmetric-key encryption scheme. That is, define the key generation algorithm, the encryption algorithm, and the decryption algorithm.

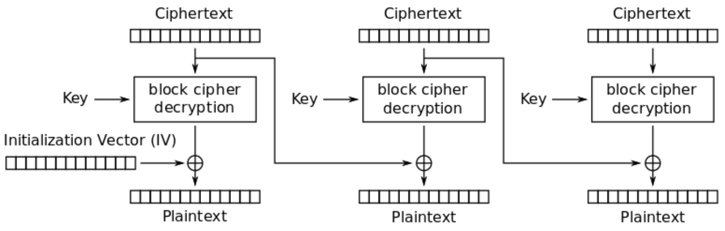
(b) Explain how using a block cipher in counter (CTR) mode is similar to the scenario described above.

Question 3 *Block cipher security and modes of operation* (20 min)

As a reminder, the cipher-block chaining (CBC) mode of operation works like this:



Cipher Block Chaining (CBC) mode encryption



Cipher Block Chaining (CBC) mode decryption

The output of the encryption is the ciphertext concatenated with the IV that was used.

(a) Does the initialization vector (IV) have to be non-repeating? Why?

(b) Imagine you sequentially picked IVs from a list of non-repeating, but publicly-known, numbers, e.g., *A Million Random Digits with 100,000 Normal Deviates* (RAND, 1955).

Say Alice encrypts the one-block long message m_1 with initialization vector IV_1 to get C_1 and encrypts m_2 using IV_2 to get C_2. She gives these to Mallory and challenges her to tell which C came from which m.

Mallory knows that Alice's next IV will be IV_3, and can ask Alice to encrypt messages for her (a *chosen plaintext attack*). Can Mallory distinguish the two ciphertexts even with this non-repeating IV?