PESU Center for
Information Security,
Forensics and
Cyber Resilience

Welcome to

PES University

Ring Road Campus, Bengaluru

PESU Center for
Information Security,
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APPLIED CRYPTOGRAPHY

Private key Systems

Lecture 3

Feistel Cipher

Used by DES

Types of Symmetric key cipher

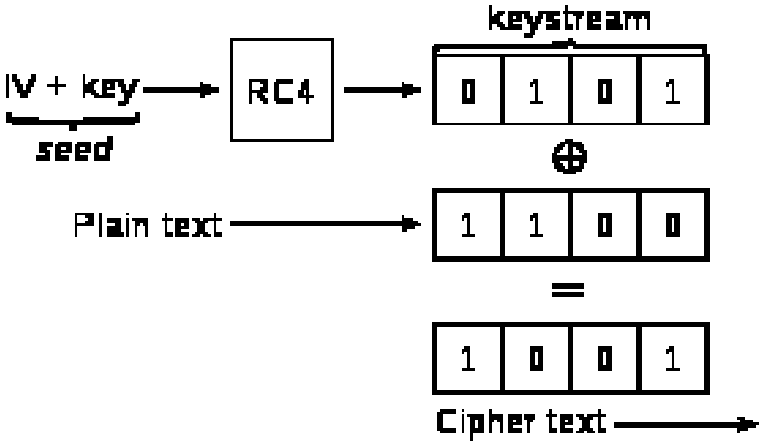
- ***Stream cipher:***
  - algorithm operates on individual bits (or bytes) one at a time
  - Example RC4 cipher system
- ***Block cipher:***
  - operates on fixed-length groups of bits called blocks
  - Example DES, Triple DES and AES

Stream Cipher (Rivest Cipher 4)

- Key stream
  - Pseudo-random sequence of bits S = S[0], S[1], S[2], …
  - Can be generated on-line one bit (or byte) at the time
- Stream cipher
  - XOR the plaintext with the key stream C[i] = S[i] ⊕ P[i]
  - Suitable for plaintext of arbitrary length generated on the fly, e.g., media stream

RC4

- **Wired Equivalent Privacy** (WEP deprecated in 2004) used the stream cipher RC4 for confidentiality.



Limitations of stream cipher

- Keystream must have a large ***period*** and it must be impossible to ***recover the cipher's key*** or internal state from the keystream.
- One never reuse the same keystream twice
    - different ***nonce or key*** must be supplied

Block cipher

- Partition the text into relatively large (e.g. 128 bits) blocks and encode each block separately.
- The encoding of each block generally depends on at most one of the previous blocks.
- The same “key” is used at each block.

Difference between block and stream ciphers

- Block ciphers work a on block / word at a time, which is some number of bits. All of these bits have to be available before the block can be processed.
- Block cipher uses either 64 bits or more than 64 bits.
- The complexity of block cipher is simple.

- Stream ciphers work on a bit or byte of the message at a time, hence process it as a “stream”.
- While stream cipher uses 8 bits.
- While stream cipher is more complex.

Difference between block and stream ciphers

- Block cipher Uses confusion as well as diffusion.
- In block cipher, reverse encrypted text is hard.
- The algorithm modes which are used in block cipher are: ECB (Electronic Code Book) and CBC (Cipher Block Chaining).

- While stream cipher uses only confusion.
- While in stream cipher, reverse encrypted text is easy.
- The algorithm modes which are used in stream cipher are: CFB (Cipher Feedback) and OFB (Output Feedback).

Confusion and diffusion

- Diffusion:
  - Refers to dissipating the statistical structure of plaintext over the bulk of ciphertext.
  - Makes statistical relationship between the plaintext and ciphertext as complex as possible

- Confusion:
  - Refers to making the relationship between the ciphertext and the symmetric key as complex and involved as possible;
  - Makes relationship between ciphertext and key as complex as possible

Block cipher design principle

- ***Block size***
  - increasing size improves security, but slows cipher
- ***Key size***
  - increasing size improves security, makes exhaustive key searching harder, but may slow cipher
- ***Number of rounds***
  - increasing number improves security, but slows cipher
- ***Subkey generation***
  - greater complexity can make analysis harder, but slows cipher
- ***Round function***
  - greater complexity can make analysis harder, but slows cipher

Feistel cipher

- Feistel Cipher is not a specific scheme of block cipher. It is a design model from which many different block ciphers are derived.
- DES is just one example of a Feistel Cipher.
- DES is a cryptographic system based on Feistel cipher structure uses the same algorithm for both encryption and decryption

History

- Feistel Cipher: the fundamental building block of DES designed by IBM.
- DES was adopted as a US federal standard for commercial encryption in 1975.
- Design requirements:
  - must provide high level of security (commercial standard)
  - Security must not depend on secrecy of algorithm (Kerckhoff’s principle)
  - Must be easily and economically implemented

Feistel cipher structure

- Horst Feistel derived the Feistel cipher based on invertible product cipher
- process
  - Partitions input block into two halves
  - process through multiple rounds which perform a substitution on left data half based on round function of right half and subkey permutation
  - swapping both left and right partition
- Implements Shannon's SP net concept

Feistel Cipher: a cipher design pattern

- Encryption :N rounds
- Plaintext = (L0, R0)

  1 <= i <= n

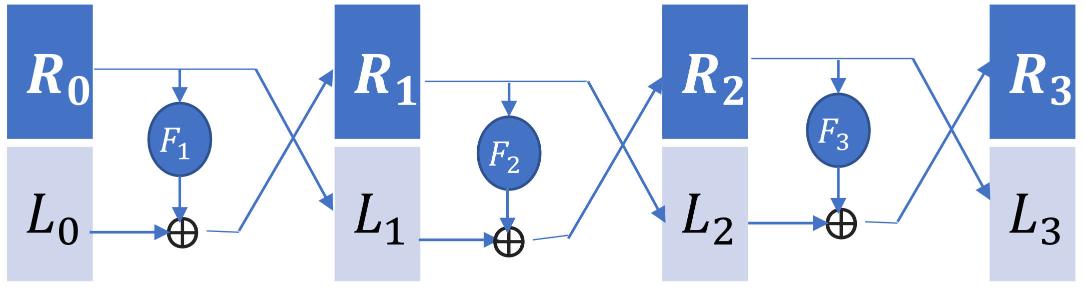
  Li = Ri-1

  Ri = Li-1 xor f(Ri-1 , Ki)

  Subkeys Ki derived from key K

  Ciphertext = (Rn, Ln) Note: swapped halves
- Decryption: As Encryption above, but subkeys applied in reverse order: N, N-1, N-2, …

Feistel Cipher for 3 rounds



input

Output

F: $K^3\ X\ \{0,1\}^{2n} \rightarrow \{0,1\}^{2n}\ is\ a\ secure\ PRP$

Page 212 FIGURE 6.5: A three-round Feistel network.

Thank you

Next Class

- ☞ Mandatory reading for the next class
  - ☞ https://www.oreilly.com/library/view/computer-security-and/9780471947837/sec9.3.html

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