Computer Security

Block ciphers

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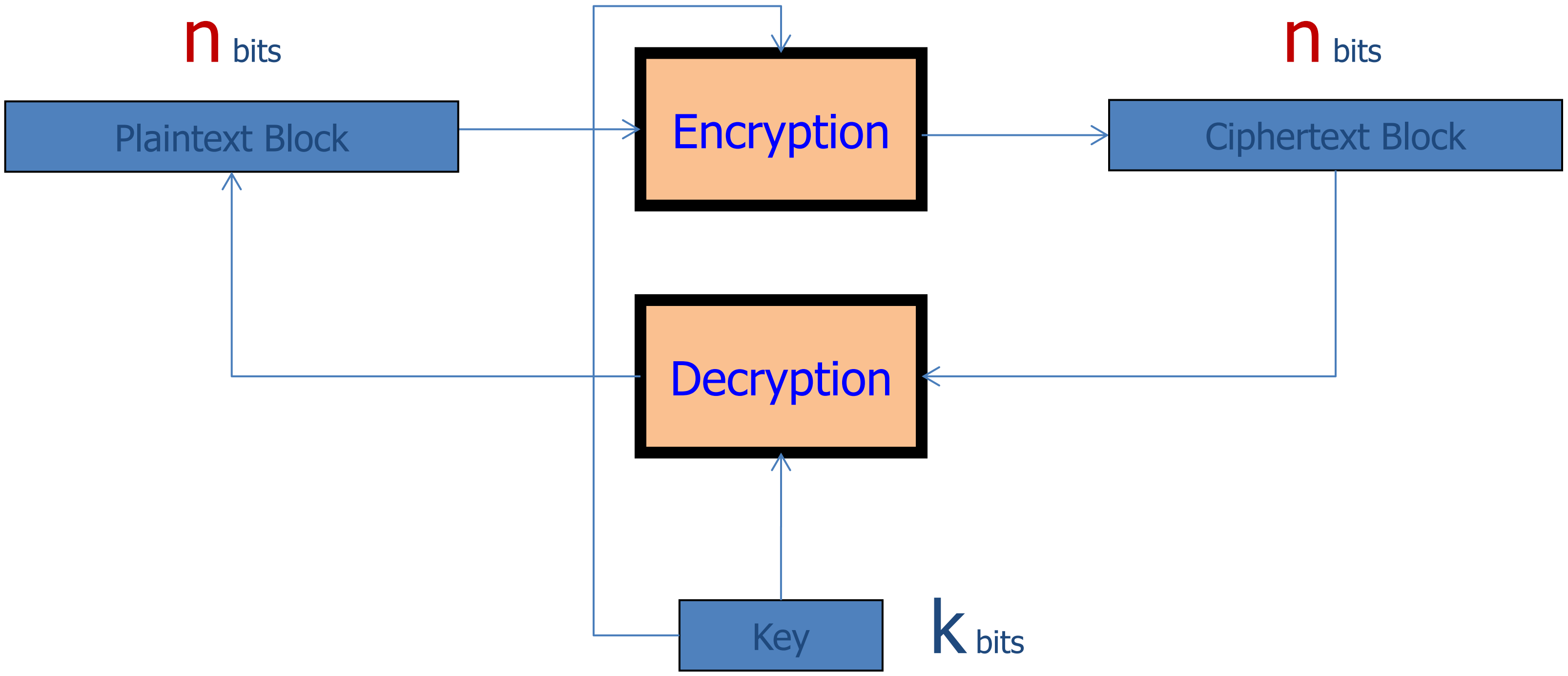
Block ciphers - basic structure

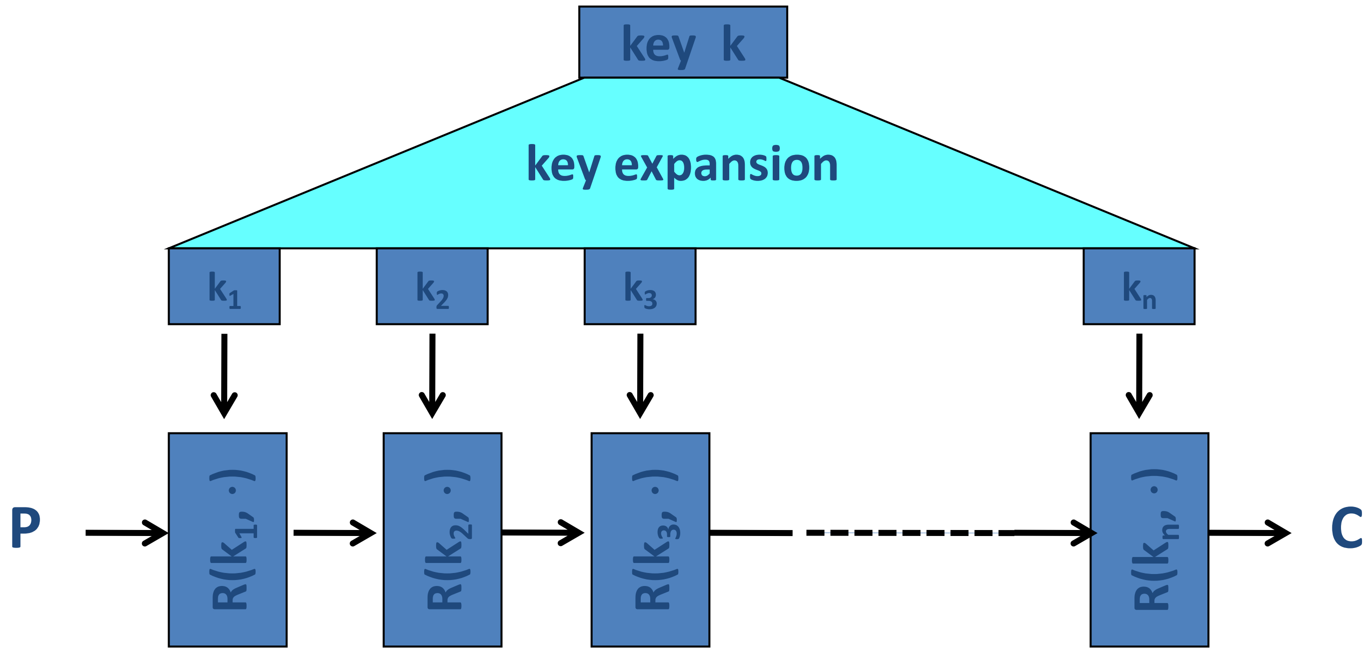


Canonical examples:

1. DES: n= 64 bits, k = 56 bits
2. AES: n=128 bits, k = 128, 192, 256 bits

Block ciphers built by iteration

Iterate substitution and permutation (by Shannon, 1948)



R(k,m) is called a round function

for DES (n=16), for AES-128 (n=10)

Cipher structures

- Feistel structure
  - This technique was devised by Horst Feistel of IBM 
  - Each round uses an operation called the F-function whose input is half a block and a round key; the output is a half-block of scrambled data which is XOR-ed into the other half-block of text
  - Examples: DES
- Substitution-Permutation (SP) networks
  - Shannon's own design for a product cipher
  - 2 layers in each round: a substitution layer provides confusion, then a permutation layer provides diffusion
  - Examples: AES

To be secure, every cipher must contain ***nonlinear*** operations.

Feistel Cipher: Encryption

- **Feistel cipher** is a type of block cipher, not a specific block cipher
- Split plaintext block into left and right halves: $P = (L_0, R_0)$
- For each round $i = 1, 2, \ldots, n$, compute

  $L_i = R_{i-1}$

  $R_i = L_{i-1} \oplus F(R_{i-1}, K_i)$

  where F is **round function** and K_i is **subkey**
- Ciphertext: $C = (L_n, R_n)$

Feistel Cipher: Decryption

- Start with ciphertext $C = (L_n, R_n)$
- For each round $i = n, n-1, \ldots, 1$, compute

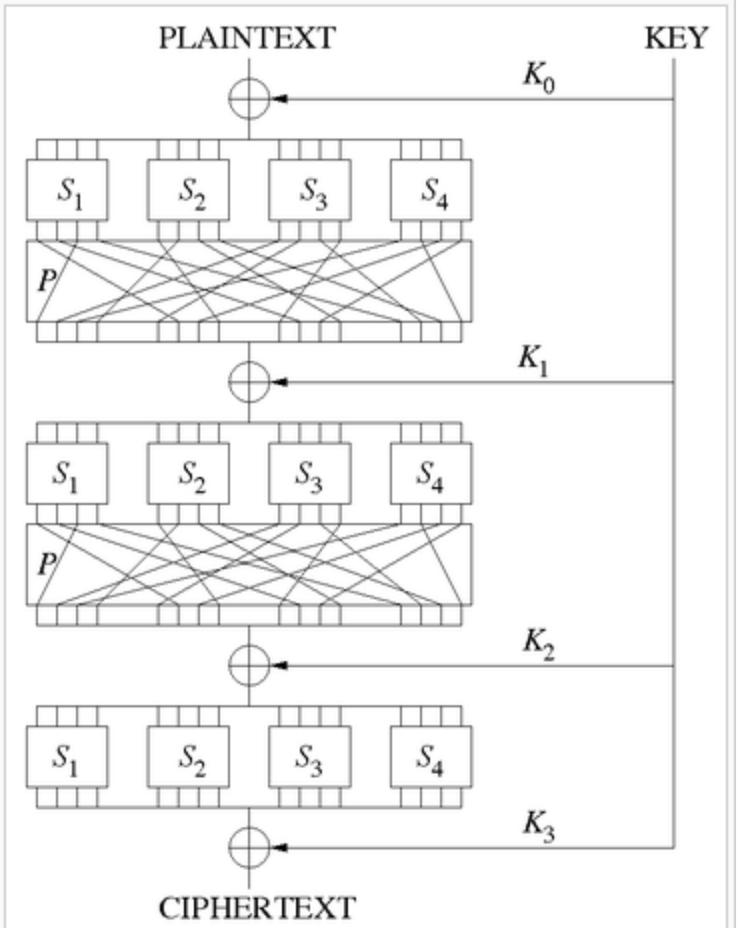
  $R_{i-1} = L_i$

  $L_{i-1} = R_i \oplus F(R_{i-1}, K_i)$

  where F is round function and K_i is subkey
- Plaintext: $P = (L_0, R_0)$
- Formula "works" for any function F
  - But only secure for certain functions F

SP networks

- More constraints on the round function: must be invertible
- Faster than Feistel-structure
- Parallel computation
- Typically E ≠ D



A sketch of a Substitution-Permutation Network with 3 rounds,

Quiz

Q1. What is the main advantage of a Feistel cipher over an SP network?

The F-function itself need not be reversible. This gives the designer extra flexibility; almost any operation he can think up can be used in the F-function

Q2. What is the main advantage of an SP network over a Feistel cipher?

In the Feistel construction, only half the output changes in each round while an SP network changes all of it in a single round

Questions?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