Data Encryption Standard

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Aim of the session

To familiarize students with an understanding of Block Cipher and Data Encryption Standard

Learning Outcomes

At the end of this session, you should be able to:

- Explain the Data Encryption Standard technique

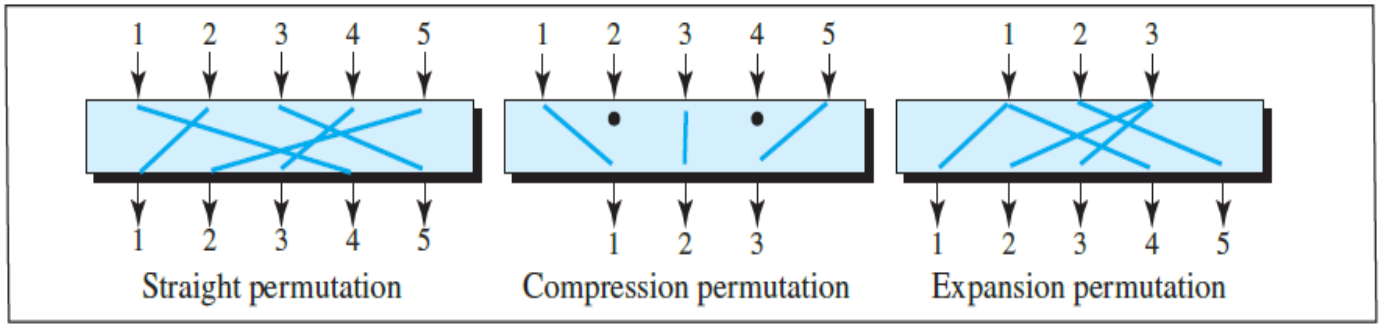
Stream and Block Ciphers

Introduction

Traditional symmetric ciphers are divided into two broad categories:

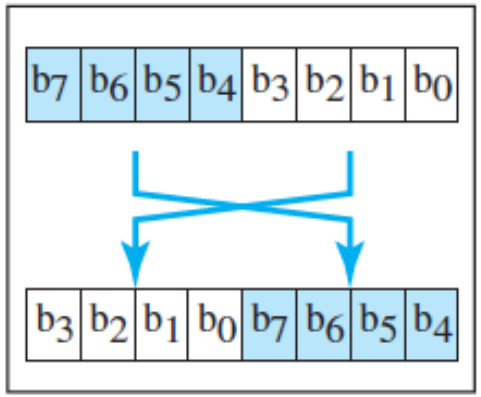
- **Stream ciphers**: Encryption and decryption are done one symbol (such as a character or a bit) at a time.
  - Given Plaintext $P = P_1P_2P_3...$; Keys $K = (k_1, k_2, k_3, ...)$
  - Ciphertext $C = C_1C_2C_3...$;
    - where $C_1 = E_{k_1}(P_1)$; $C_2 = E_{k_2}(P_2)$; $C_3 = E_{k_3}(P_3)$..
- **Block ciphers**: A group of plaintext symbols of size $m(m > 1)$ are encrypted together
  - The ciphertext is of the same size
  - A single key is used to encrypt the whole block even if the key is made up of multiple values.

Operations in Block Ciphers

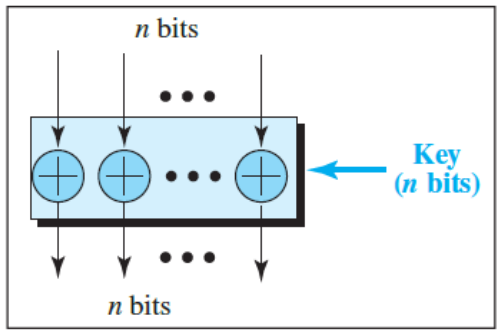


Transposition

Figure: P-Box



Swap



Exclusive-OR

Data Encryption Standard

- DES is an example of a modern block cipher
- DES takes a 64-bit plaintext and creates a 64-bit ciphertext
- **56-bit cipher key** is used for both encryption and decryption.

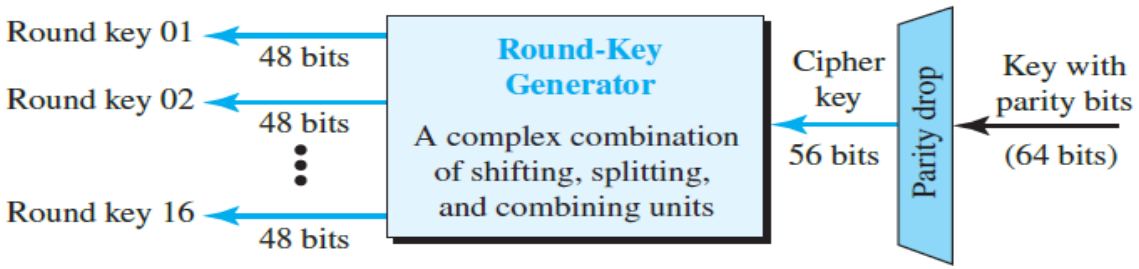


Figure: Key generation

- Cipher key is normally a 64-bit key in which 8 extra bits are the parity bits
- Parity bits are dropped before the actual key-generation process
- Round-key generator creates sixteen 48-bit keys out of a 56-bit cipher key.

Data Encryption Standard

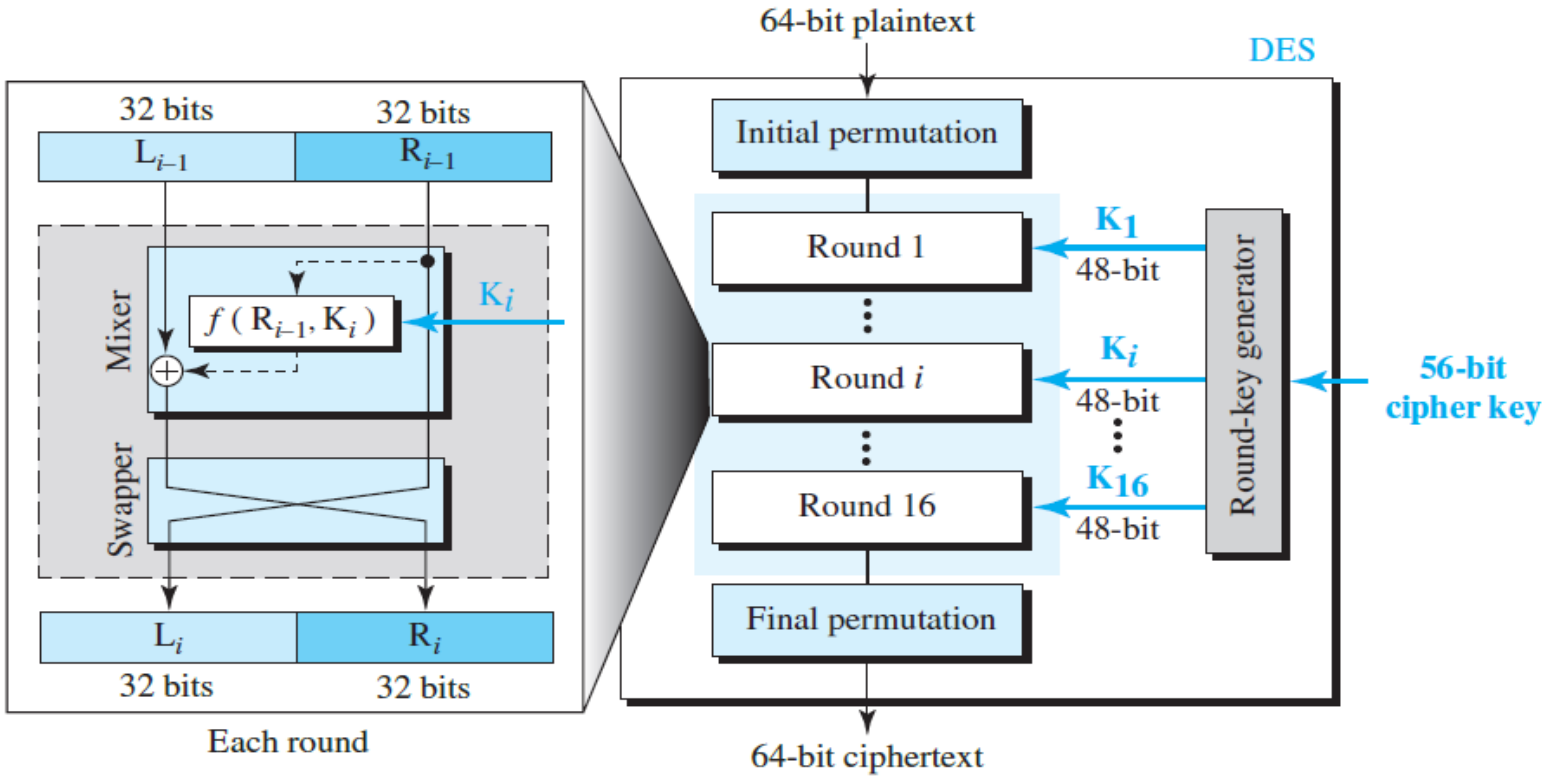


Figure: Structure of DES

Data Encryption Standard

- **Step 1**: Generate Keys for 16 rounds
- **Step 2: Initial permutation** takes a 64-bit input and permutes them according to a predefined rule.
- **Step 3: Rounds**: Each round takes L_{i-1} and R_{i-1} from the previous round and creates L_i and R_i
  - Each round can have up to two cipher elements: Mixer(XOR) and swapper
- **Final permutation** is the inverse of the initial permutation

DES Function

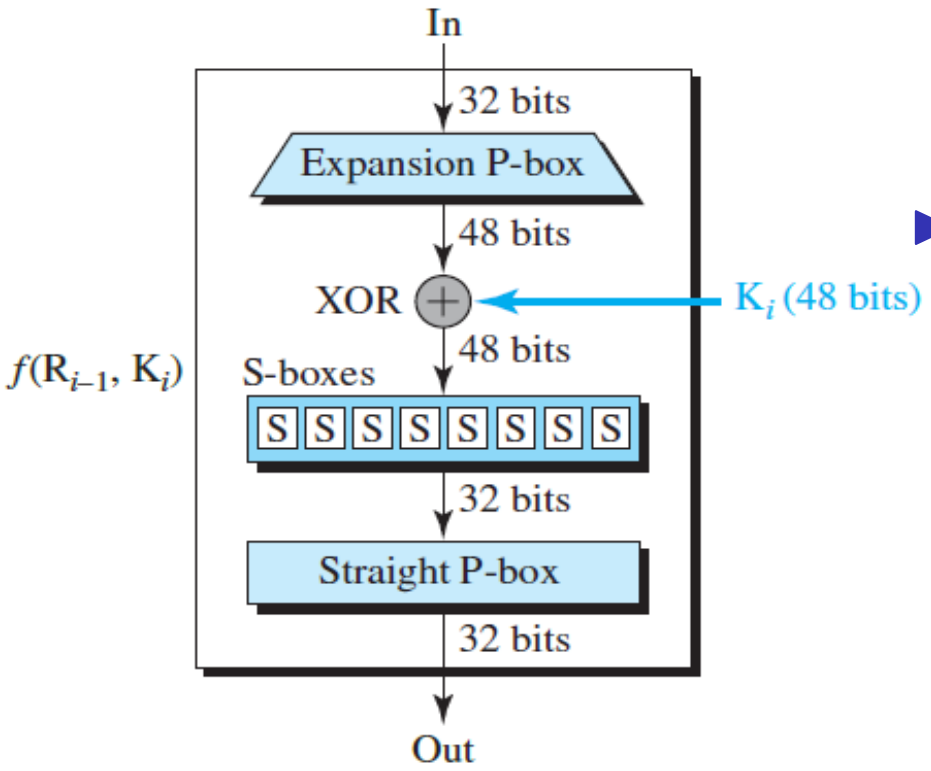


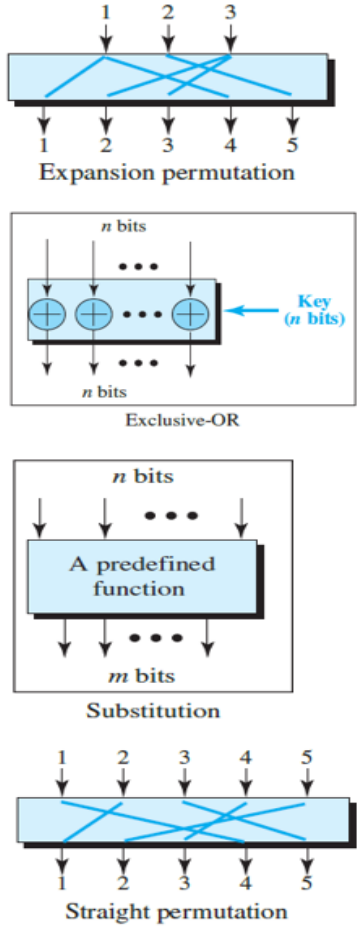
Figure: DES Function

- The DES function applies a 48-bit key to the rightmost 32 bits R_{i-1} to produce a 32-bit output

DES Function

Four Sections:

- **Expansion P-box**: Permutation Box. converts 32 bits to 48 bits
- **Whitener** : XOR Operation with the round key
- **Group of S-boxes**: Eight S-boxes, each with a 6-bit input and a 4-bit output.
  - S-box $\Longrightarrow$ Substitution box
- **Straight P-box**: Straight permutation with a 32-bit input and a 32-bit output



Simplified Data Encryption Standard (S-DES)

Feature	**DES**	**S-DES**
Block Size	64 bits	8 bits
Key Size	56 bits	10 bits
Rounds	16	2
Purpose	Symmetric Encryption	Education Tool
Security	Vulnerable to attack	Not designed for security

For Numerical Example on S-DES, refer:
`https://medium.com/@np01nt4s220042/simplified-data-encryption-standard-8ab7061eaa3c`

Acknowledge various sources for the images.
Thankyou