SNS COLLEGE OF ENGINEERING

Kurumbapalayam(Po), Coimbatore – 641 107

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DEPARTMENT OF INFORMATION TECHNOLOGY

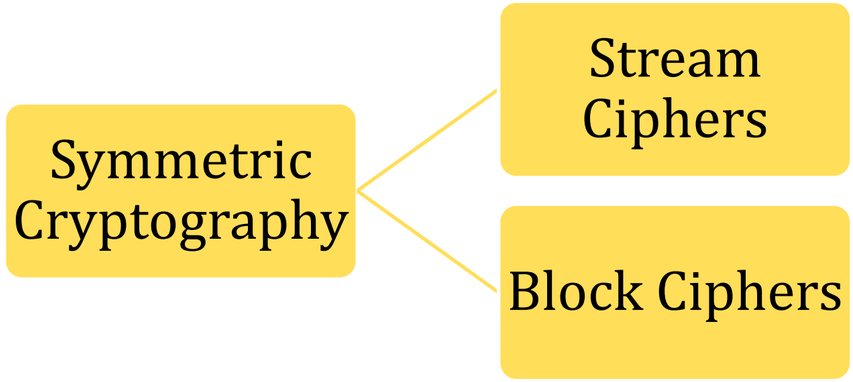
Course Code and Name : 19IT602– CRYPTOGRAPHY AND CYBER SECURITY

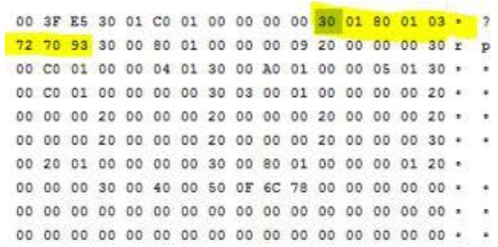
III YEAR / VI SEMESTER

Unit 2: SYMMETRIC KEY CRYPTOGRAPHY

Topic : Data Encryption Standard

RECAP : STREAM AND BLOCK CIPHERS



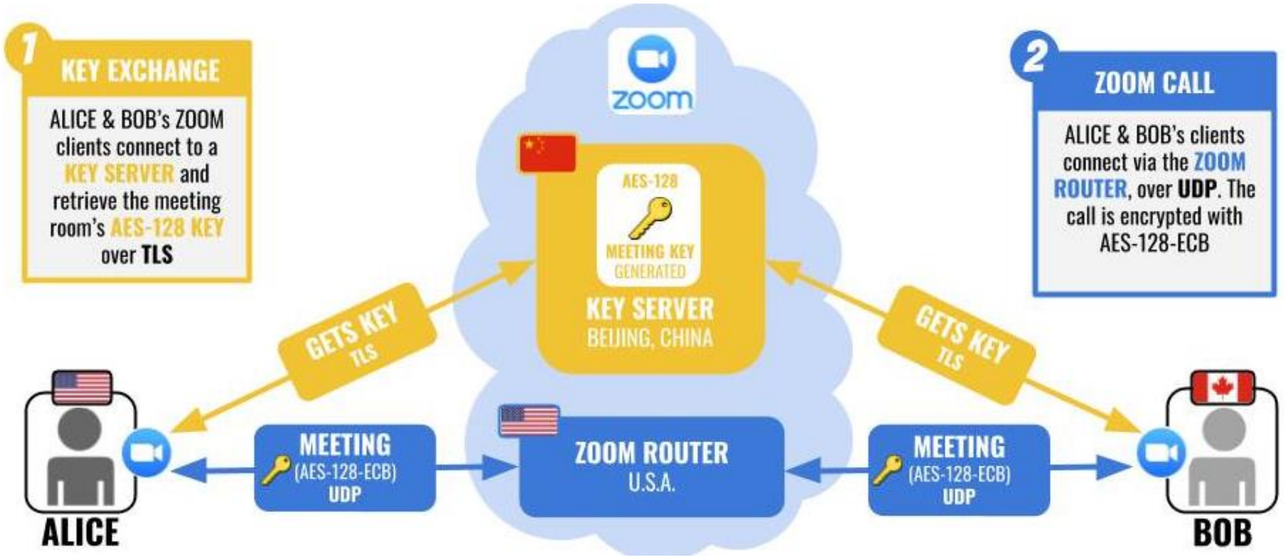


- **Stream ciphers** process messages a bit or byte at a time when en/decrypting
- **Block ciphers** process messages into blocks, each of which is then en/decrypted
- Simple substitution is an example of a stream cipher.
- Columnar transposition is a block cipher

ACTIVITY

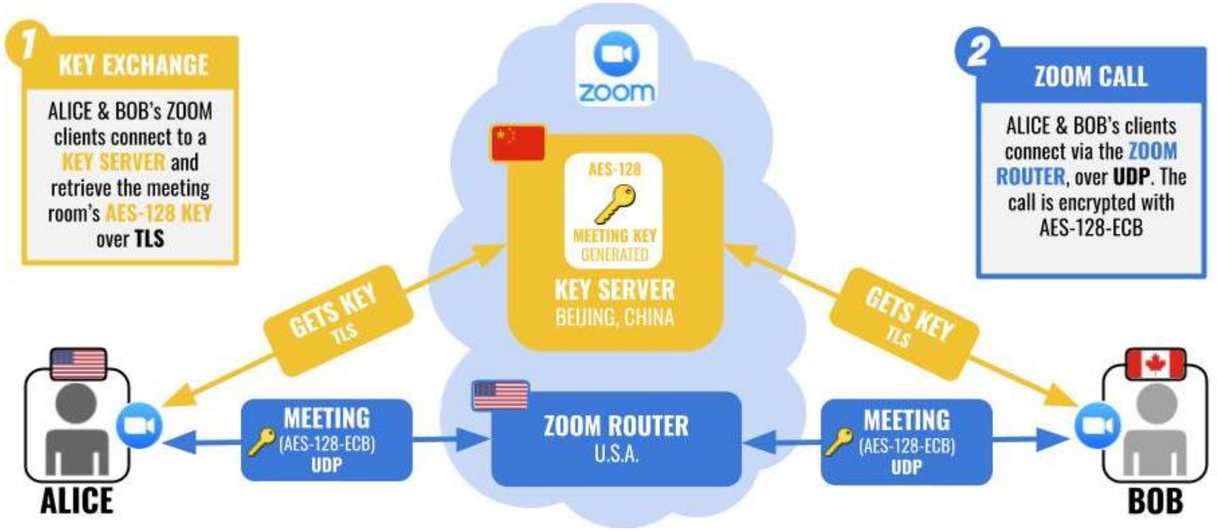
Identify what is this?

How DES is Used here?



DATA ENCRYPTION STANDARD

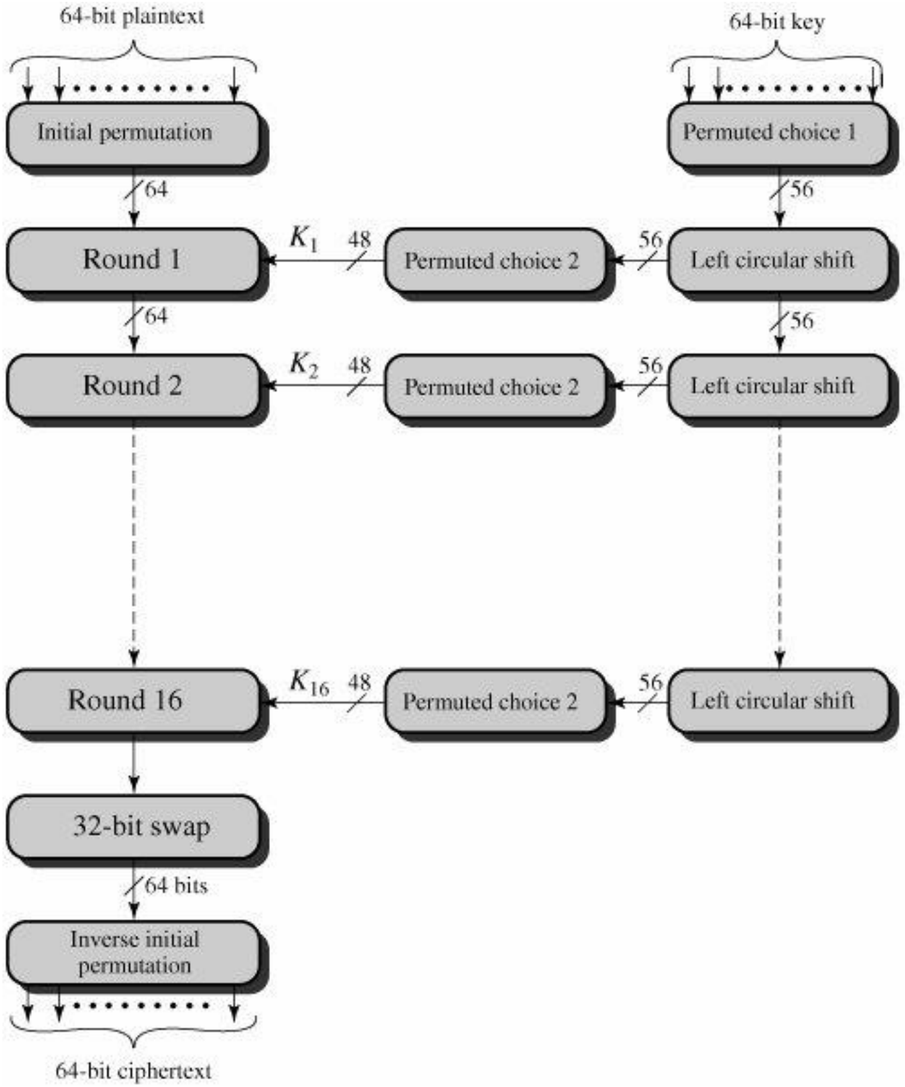
- Most widely used encryption scheme
- Adopted in 1977 by National Bureau Standards (Now National Institute of Standards and Technology NIST) as Federal Information Processing Standards 46 (FIPS PUB 46)
- Data Encrypted in 64 bit blocks using 56 bit key (Transforms 64 bit input into 64 bit output)



DES - HISTORY

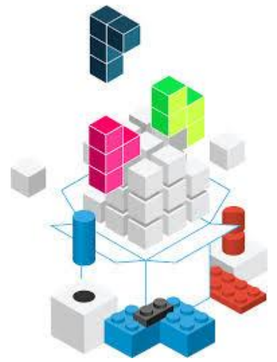
1971	1973	1977
IBM developed Lucifer cipher by team led by Feistel	NBS issued request for proposals for a national cipher standard	IBM submitted their revised Lucifer which was eventually accepted as the DES

GENERAL STRUCTURE OF DES



Core Components of DES

- Initial Permutation
- Round Function
- Permuted Choice 1
- Permuted Choice 2
- Left Circular Shift
- 32 – Bit Swap
- Inverse Initial Permutation



DES COMPONENTS EXPLAINED

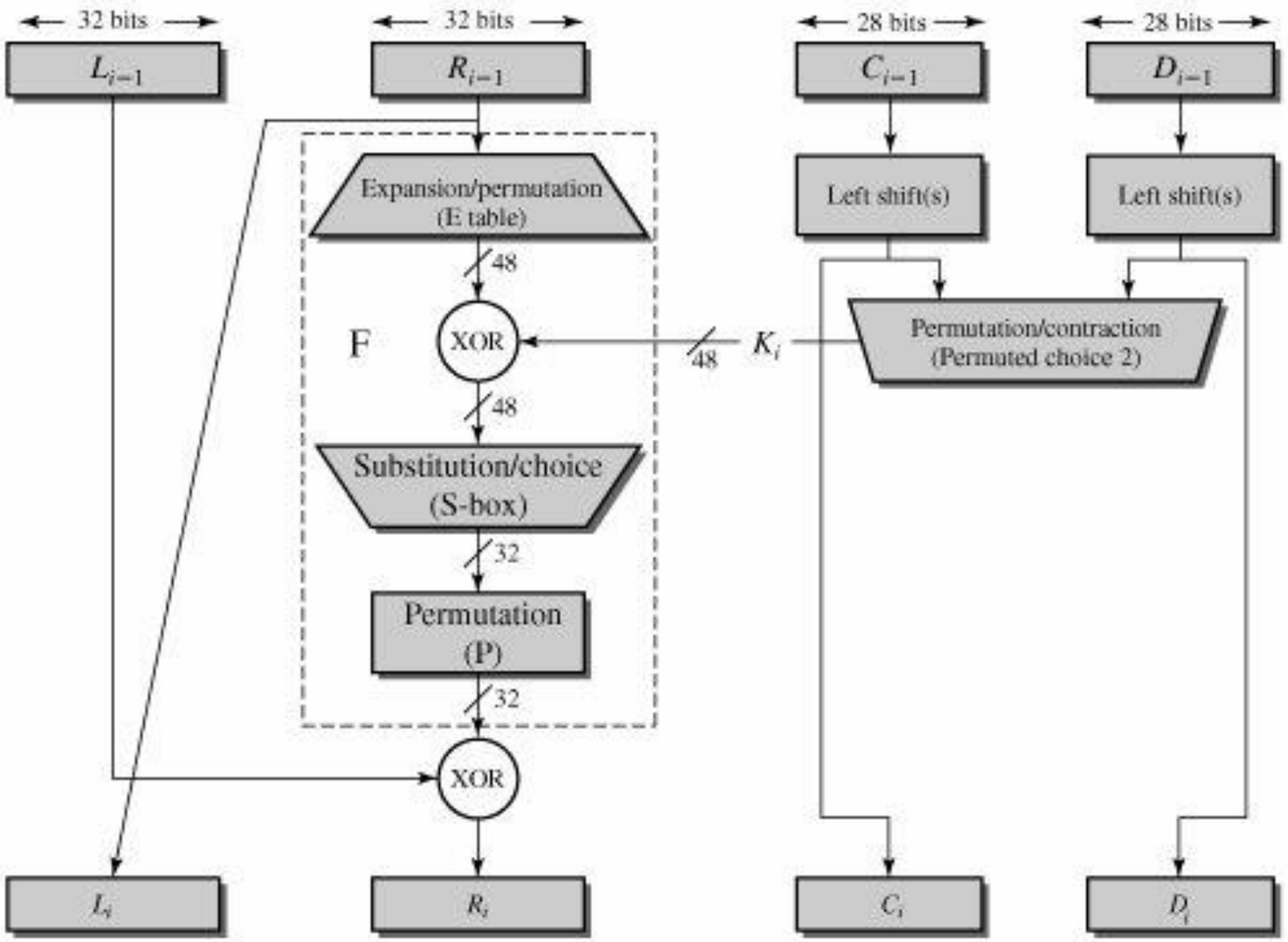
Input M

1	2	3	4	5	6	7	8
9	10	11	12	13	14	15	16
17	18	19	20	21	22	23	24
25	26	27	28	29	30	31	32
33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48
49	50	51	52	53	54	55	56
57	58	59	60	61	62	63	64

Initial Permutation

58	50	42	34	26	18	10	2
60	52	44	36	28	20	12	4
62	54	46	38	30	22	14	6
64	56	48	40	32	24	16	8
57	49	41	33	25	17	9	1
59	51	43	35	27	19	11	3
61	53	45	37	29	21	13	5
63	55	47	39	31	23	15	7

SINGLE ROUND OF DES



ROUND FUNCTION - Components

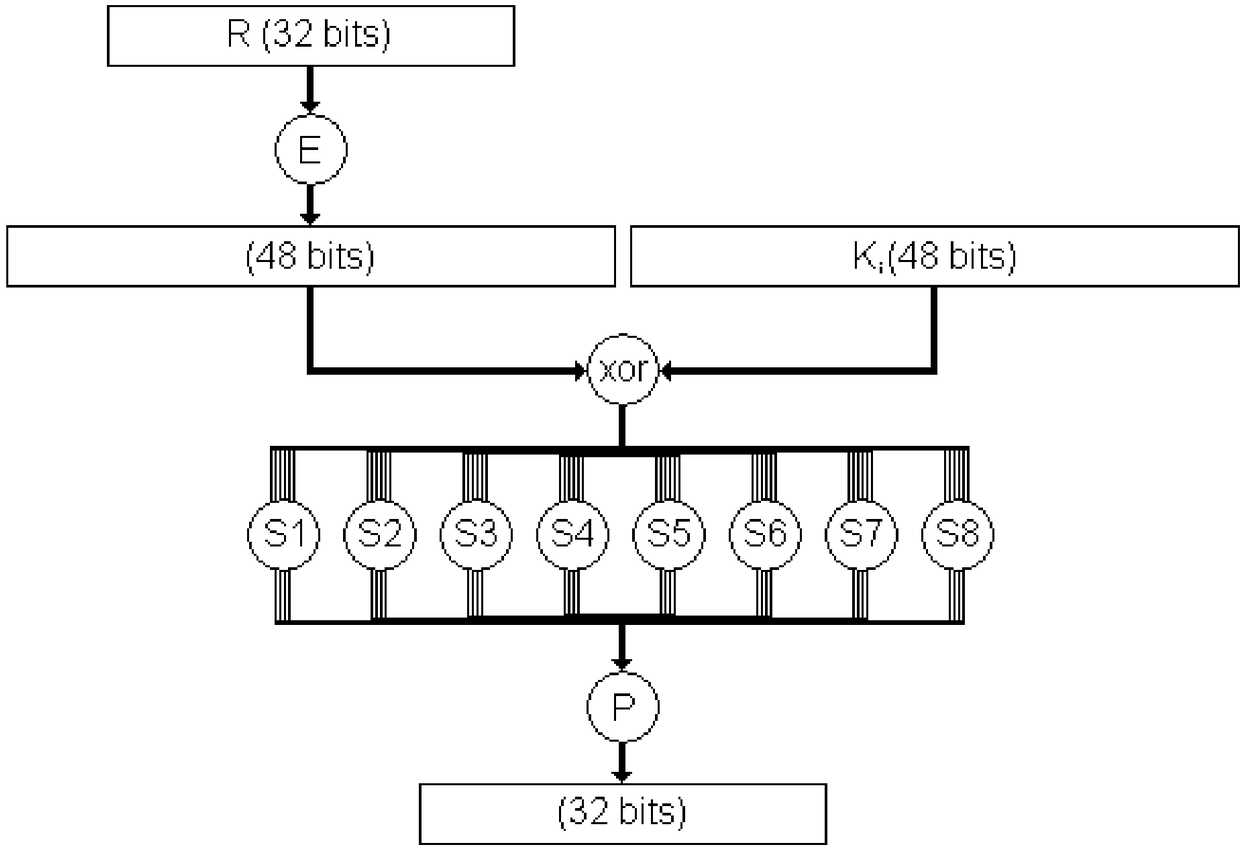
Expansion Permutation E

32	1	2	3	4	5
4	5	6	7	8	9
8	9	10	11	12	13
12	13	14	15	16	17
16	17	18	19	20	21
20	21	22	23	24	25
24	25	26	27	28	29
28	29	30	31	32	1

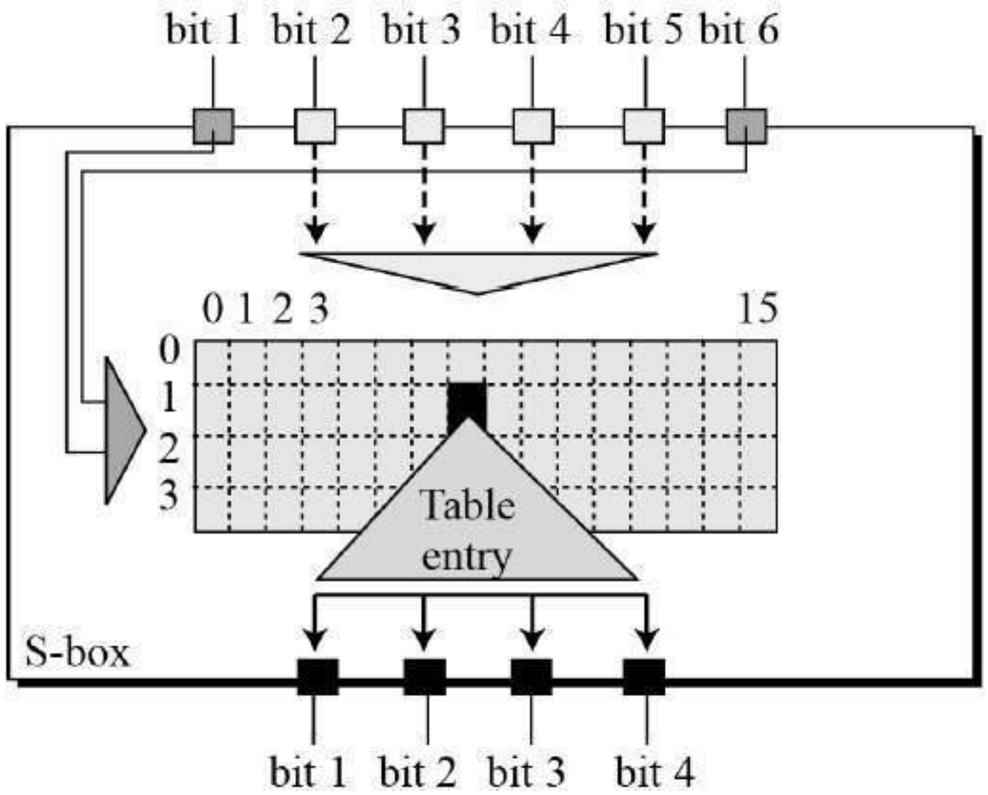
Permutation Function P

16	7	20	21	29	12	28	17
1	15	23	26	5	18	31	10
2	8	24	14	32	27	3	9
19	13	30	6	22	11	4	25

S-Box



SINGLE S- BOX in Detail



S - Box 1															
14	4	13	1	2	15	11	8	3	10	6	12	5	9	0	7
0	15	7	4	14	2	13	1	10	6	12	11	9	5	3	8
4	1	14	8	13	6	2	11	15	12	9	7	3	10	5	0
15	12	8	2	4	9	1	7	5	11	3	14	10	0	6	13

S - Box 2															
15	1	8	14	6	11	3	4	9	7	2	13	12	0	5	10
3	13	4	7	15	2	8	14	12	0	1	10	6	9	11	5
0	14	7	11	10	4	13	1	5	8	12	6	9	3	2	15
13	8	10	1	3	15	4	2	11	6	7	12	0	5	14	9

PERMUTATION CHOICE 1

Input Key

1	2	3	4	5	6	7	8
9	10	11	12	13	14	15	16
17	18	19	20	21	22	23	24
25	26	27	28	29	30	31	32
33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48
49	50	51	52	53	54	55	56
57	58	59	60	61	62	63	64

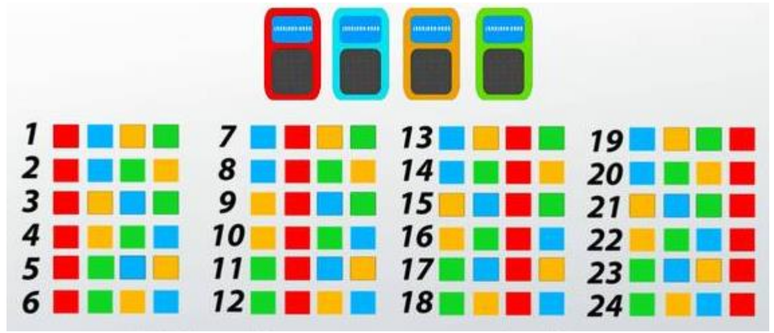
Permutation Choice 1(PC 1)

57	49	41	33	25	17	9
1	58	50	42	34	26	18
10	2	59	51	43	35	27
19	11	3	60	52	44	36
63	55	47	39	31	23	15
7	62	54	46	38	30	22
14	6	61	53	45	37	29
21	13	5	28	20	12	4

PERMUTATION CHOICE 2 & LEFT CIRCULAR SHIFT

Permutation Choice 2(PC 2)

14	17	11	24	1	5	3	28
15	6	21	10	23	19	12	4
26	8	16	7	27	20	13	2
41	52	31	37	47	55	30	40
51	45	33	48	44	49	39	56
34	53	46	42	50	36	29	32



Schedule of left shift

Round	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Bits Shifted	1	1	2	2	2	2	2	2	1	2	2	2	2	2	2	1

DES ANALYSIS

Avalanche effect – A small change in plaintext results in the very grate change in the ciphertext

Completeness – Each bit of ciphertext depends on many bits of plaintext.

STRENGTH OF DES

Key Size

- 56-bit keys have $2^{56} = 7.2 \times 10^{16}$ values
- brute force search looks hard
- recent advances have shown is possible
  - in 1997 on Internet in a few months
  - in 1998 on dedicated h/w (EFF) in a few days
  - in 1999 above combined in 22hrs!
- still must be able to recognize plaintext
- must now consider alternatives to DES

Schedule of left shift

- attacks actual implementation of cipher
- use knowledge of consequences of implementation to derive information about some/all subkey bits
- specifically use fact that calculations can take varying times depending on the value of the inputs to it
- particularly problematic on smartcards

REFERENCES

William Stallings, Cryptography and Network Security: Principles and Practice, PHI 3rd Edition, 2006.

THANK YOU