The University of Newcastle
School of Electrical Engineering and Computer Science

COMP3260 Data Security
Assignment 2

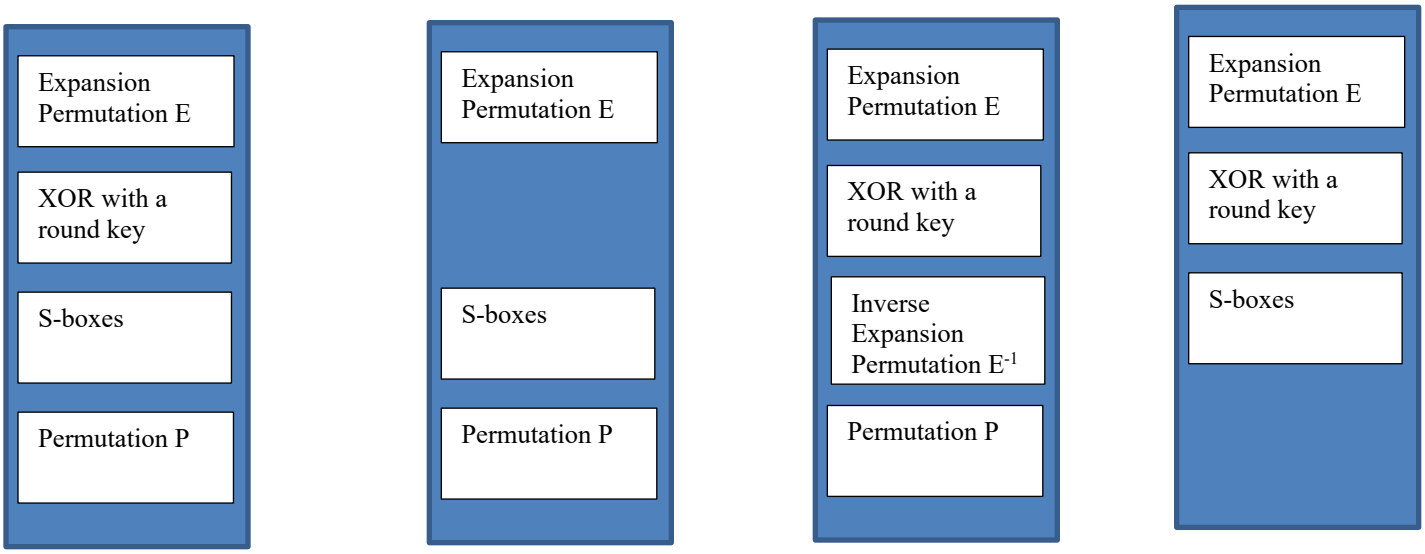
Due on Wednesday, 7th May 2021, end of day, in the Assignment 2 in Blackboard.
Total mark: 100

Note:
Before you start working on the Assignment please read the information on academic integrity, which can be found at http://www.newcastle.edu.au/service/academic-integrity/. All available strategies will be used for detecting possible plagiarism and all suspicious cases will be referred to the SACO (Student Academic Conduct Officer).

In this assignment you will implement DES encryption and decryption of a single plaintext block. Your program will take as input a 64-bit plaintext block and a 64-bit key block (note that only 56 bits of those will be selected by PC-1) and produce as output a 64 bit ciphertext block. You will use your implementation to explore the Avalanche effect of the original DES denoted as DES0, as well as DES1, DES2, and DES3, where in each version an operation is missing in each round as follows:

0. DES0 - the original version of DES
1. DES1 – XOR with a round key is missing from F function in all rounds
2. DES2 – S-boxes are missing from F function in all rounds; instead, inverse E^{-1} of the Expansion Permutation E is used for contraction from 48 down to 32 bits
3. DES3 – Permutation P is missing from F function in all rounds

For additional clarity, the encryption algorithm for the four versions of DES is given in the picture bellow.



DES0 **DES1** **DES2** **DES3**

In addition to the original plaintext block P and the key K, your program should use 64 other plaintext blocks P_i, $1 \leq i \leq 64$, and 56 other keys K_i, $1 \leq i \leq 56$, such that each P_i differs from P only in bit i and each K_i differs from K only in bit i, and use them to explore the Avalanche effect in DES as follows.

The program will encrypt plaintext P under key K. Then it will encrypt plaintext P_1 under key K and it will find the number of different bits after each of the 16 rounds between P under K, and P_1 under K. Then the above will be repeated for each of the remaining 63 plaintexts P_i that differ from P in a single bit and the average results for all 64 plaintexts will be presented in the output.

Similarly, your program will encrypt plaintext P under key K_1 and it will find the number of different bits after each of the 16 rounds between P under K, and P under K_1. Then the above will be repeated for each of the remaining 55 keys K_i that differ from K in a single bit, and the average results for all 56 keys will be presented in the output.

Your program MUST be well commented, include a header stating the authors and purpose of the program, and be easy to understand. You MUST NOT use any available DES code or a portion of it.

ENCRYPTION: INPUT FILE

The following is an example of an input file, where the first row is the plaintext P and the second row is key K.

```
000…0
111…0
```

OUTPUT FILE

The following is a format of an output file (note that the numbers provided are sample values and not necessarily what you will obtain for different inputs):

ENCRYPTION
Plaintext P: 000…0
Key K: 111…0
Ciphertext C: 010…0
Running time: XXX

Avalanche:

P and P_i under K

Round	DES0	DES1	DES2	DES3
0	1	1	1	1
1	5	etc		
2	20			
3	30			
4	31			
5	34			
6	32			
7	29			
8	36			
9	41			
10	38			
11	29			
12	33			

13	39
14	36
15	40
16	37

P under K and K_i

Round	DES0	DES1	DES2	DES3
0	0	etc		
1	2			
2	18			
3	27			
4	33			
5	41			
6	30			
7	34			
8	37			
9	29			
10	33			
11	40			
12	37			
13	43			
14	38			
15	29			
16	35			

In the above, 'Round 0' refers to the plain text before the beginning of the encryption. The column DESi contains the number of bits that differ between the original plaintext P, and the intermediate result in each round of the encryption performed by DESi defined above.

DECRYPTION: For decryption, the INPUT FILE should contain the ciphertext and the key, and the OUTPUT FILE should contain the ciphertext, the key and the plaintext.

The following is an example of an input file:

```
0000…0
111…0
```

The following is a format of an output file (note that the numbers provided are sample values and not necessarily what you will obtain for different inputs):

```
DECRYPTION
Ciphertext C: 000…0
Key K: 111…0
Plaintext P: 010…0
```

PROGRAM REQUIREMENTS

Assignment may be completed in Java or C++. If you would like to us another programming language, please first obtain a permission from your marker Aaron Freemantle < Aaron.Freemantle@uon.edu.au>. Other programming requirements will be published shortly.

Assessment criteria:

1	DES encryption and decryption – working and correct	55
2	Avalanche analysis, correct	35
3	Comments throughout the program	10
	TOTAL	100

If your DES encryption and decryption are not working correctly you can score at most 40 marks in total.