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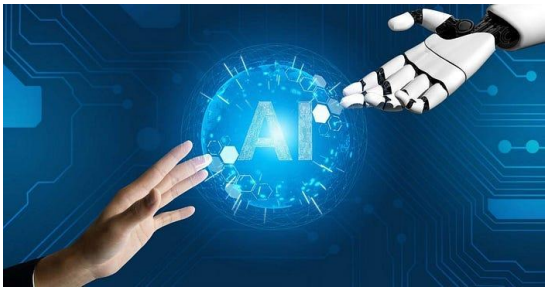
UNIVERSITE CRETIENNE BILINGUE DU CONGO/ UCBC

UNIVERSITÉ CHRÉTIENNE BILINGUE DU CONGO

CRYPTOLOGY FINAL PROJECT

TOPIC: SEARCH ON ENCRYPTION OF MEDICAL INFORMATIONS



Work made and realized by: MUNGUAHANA BUJIRIRI David

Searcher in computer Engineering L3

Supervisor team: SAGE KATALIKO

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I. INTRODUCTION

o Contexte

La santé est un sujet de recherche complexe car elle touche une grande partie de la capacité de réflexion, l'efficacité, la productivité et la croissance d'une population en général et d'une personne en particulier. La santé est précieuse pour l'homme cependant, la maladie est fatale ; depuis la chute de l'homme, la souffrance, la mort, les actions de démons, les épreuves de la foi sont des châtiments divins qui ont été à l'origine de la maladie. Ainsi, La complexité de ce domaine met en cause les différents défis et opportunités auxquelles l'être humain se confronte en cherchant et en recherchant des solutions pour parvenir à augmenter l'efficacité, la précision, la concision et l'efficience dans les traitements des maladies dans le but de rendre la santé de plus en plus sûre pour la population, protégée et promu d'autant plus que jusque-là il est impossible d'éradiquer la maladie dans le monde.

La santé étant un domaine en constante évolution, avec de nouveaux défis et de nouvelles opportunités qui émergent chaque jour ; L'intelligence artificielle (IA) a le potentiel de révolutionner la santé en offrant des solutions innovantes pour améliorer la qualité des soins, l'efficacité des systèmes de santé et l'accès aux services de santé pour tous. Les développeurs, les chercheurs de ce domaine dans le monde travaillent constamment pour améliorer du jour au jour la qualité et les performances dans le traitement de la maladie.

Toutefois, les données médicales étant sensible, elles doivent être le plus sécurisées pour éviter des cas de leurs utilisations abusives par certaines personnes mal intentionnées. Les données médicales doivent être chiffrer et être accessible seulement par des personnes autorisées.

Ce travail sera une étude et une implémentation d'un algorithme de chiffrement des données médicales avec le standard de chiffrement DES (Data Encryption Standard).

o Méthodologie

Ce travail sera réalisé en anglais et en français. Nous allons consulter quelques articles et livres pour nous permettre d'acquérir des connaissances sur ce standard d chiffrement.

Nous allons utiliser l'environnement VISUAL STUDIO CODE pour implémenter les Template (HTML, CSS et JAVE SCRIPT) et aussi nous allons utiliser le langage de programmation Python avec le frame work FLASK pour l'implémentation de la fonction de chiffrement et la connexion avec notre base de données dans MYSQL.

o Objectif

Par cette recherche et travail, nous voulons utiliser un standard de chiffrement DES, Data Encryption Standard pour chiffrer les données et les informations médicales d'un patient. Pour cette première version nous allons juste concentrer notre étude sur

l'algorithme de chiffrement que nous aurons bien sûre à chaque fois améliorer dans chacune des versions suivantes.

II. THEORIE SUR L'ALGORITHME DE CHIFREMENT UTILISE

Data encryption standard (DES) | Set 1

This article talks about the Data Encryption Standard (DES), a historic encryption algorithm known for its 56-bit key length. We explore its operation, key transformation, and encryption process, shedding light on its role in data security and its vulnerabilities in today's context.

What is DES?

Data Encryption Standard (DES) is a block cipher with a 56-bit key length that has played a significant role in data security. Data encryption standard (DES) has been found vulnerable to very powerful attacks therefore, the popularity of DES has been found slightly on the decline. DES is a block cipher and encrypts data in blocks of size of 64 bits each, which means 64 bits of plain text go as the input to DES, which produces 64 bits of ciphertext. The same algorithm and key are used for encryption and decryption with minor differences. The key length is 56 bits.

The basic idea is shown below:

We have mentioned that DES uses a 56-bit key. Actually, The initial key consists of 64 bits. However, before the DES process even starts, every 8th bit of the key is discarded to produce a 56-bit key. That is bit positions 8, 16, 24, 32, 40, 48, 56, and 64 are discarded.

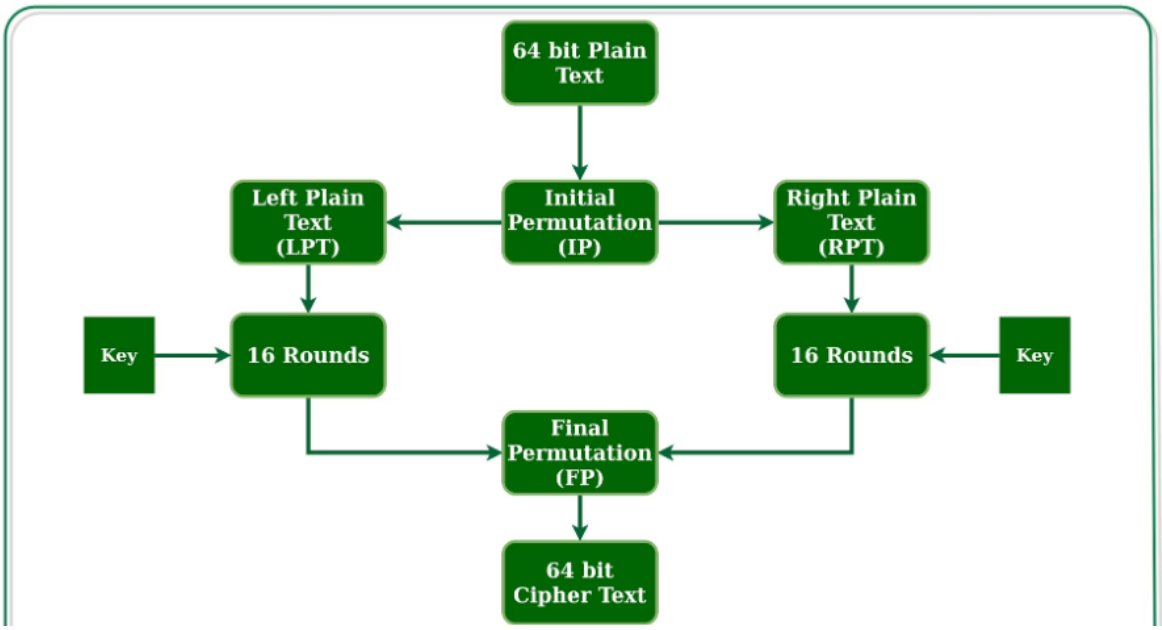
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64

Figure - discording of every 8th bit of original key

Thus, the discarding of every 8th bit of the key produces a 56-bit key from the original 64-bit key.
DES is based on the two fundamental attributes of cryptography: substitution (also called confusion) and transposition (also called diffusion). DES consists of 16 steps, each of which is called a round. Each round performs the steps of substitution and transposition. Let us now discuss the broad-level steps in DES.

- In the first step, the 64-bit plain text block is handed over to an initial Permutation (IP) function.

- The initial permutation is performed on plain text.
- Next, the initial permutation (IP) produces two halves of the permuted block; saying Left Plain Text (LPT) and Right Plain Text (RPT).
- Now each LPT and RPT go through 16 rounds of the encryption process.
- In the end, LPT and RPT are rejoined and a Final Permutation (FP) is performed on the combined block
- The result of this process produces 64-bit ciphertext.



Initial Permutation (IP)

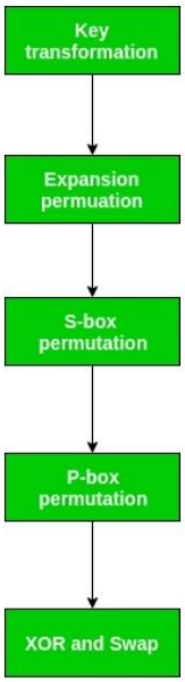
As we have noted, the initial permutation (IP) happens only once and it happens before the first round. It suggests how the transposition in IP should proceed, as shown in the figure. For example, it says that the IP replaces the first bit of the original plain text block with the 58th bit of the original plain text, the second bit with the 50th bit of the original plain text block, and so on.

This is nothing but jugglery of bit positions of the original plain text block. the same rule applies to all the other bit positions shown in the figure.

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	33	45	37	29	21	13	5	63	55	47	39	31	23	15	7

Figure - Initial permutation table

As we have noted after IP is done, the resulting 64-bit permuted text block is divided into two half blocks. Each half-block consists of 32 bits, and each of the 16 rounds, in turn, consists of the broad-level steps outlined in the figure.



Step 1: Key transformation

We have noted initial 64-bit key is transformed into a 56-bit key by discarding every 8th bit of the initial key. Thus, for each a 56-bit key is available. From this 56-bit key, a different 48-bit Sub Key is generated during each round using a process called key transformation. For this, the 56-bit key is divided into two halves, each of 28 bits. These halves are circularly shifted left by one or two positions, depending on the round.

For example: if the round numbers 1, 2, 9, or 16 the shift is done by only one position for other rounds, the circular shift is done by two positions. The number of key bits shifted per round is shown in the figure.

Round	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
#key bits shifted	1	1	2	2	2	2	2	2	1	2	2	2	2	2	2	1

Figure - number of key bits shifted per round

After an appropriate shift, 48 of the 56 bits are selected. From the 48 we might obtain 64 or 56 bits based on requirement which helps us to recognize that this model is very versatile and can handle any range of requirements needed or provided. for selecting 48 of the 56 bits the table is shown in the figure given below. For instance, after the shift, bit number 14 moves to the first position, bit number 17 moves to the second position, and so on. If we observe the table , we will realize that it contains only 48-bit positions. Bit number 18 is discarded (we will not find it in the table), like 7 others, to reduce a 56-bit key to a 48-bit key. Since the key transformation process involves permutation as well as a selection of a 48-bit subset of the original 56-bit key it is called Compression Permutation.

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

Figure - compression permutation

Because of this compression permutation technique, a different subset of key bits is used in each round. That makes DES not easy to crack.

Step 2: Expansion Permutation

Recall that after the initial permutation, we had two 32-bit plain text areas called Left Plain Text(LPT) and Right Plain Text(RPT). During the expansion permutation, the RPT is expanded from 32 bits to 48 bits. Bits are permuted as well hence called expansion permutation. This happens as the 32-bit RPT is divided into 8 blocks, with each block consisting of 4 bits. Then, each 4-bit block of the previous step is then expanded to a corresponding 6-bit block, i.e., per 4-bit block, 2 more bits are added.

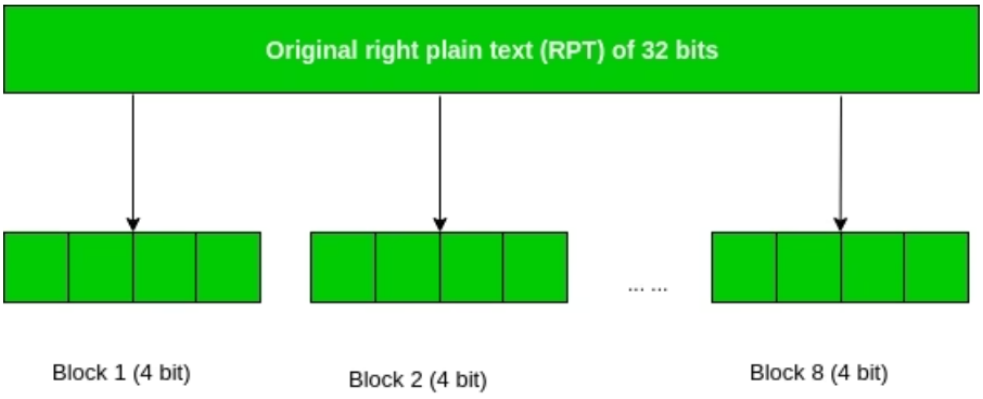


Figure - division of 32 bit RPT into 8 bit blocks

In this document we are going to show how in general DES standard works even that for us we just import DES in our python file to be more simple. Below is the full process for how to encrypt information using DES standard:

```
 # Hexadecimal to binary conversion

def hex2bin(s):

    mp = {'0': "0000",

          '1': "0001",

          '2': "0010",

          '3': "0011",

          '4': "0100",

          '5': "0101",

          '6': "0110",

          '7': "0111",

          '8': "1000",

          '9': "1001",

          'A': "1010",
```

```
          'B': "1011",
          'C': "1100",
          'D': "1101",
          'E': "1110",
          'F': "1111"}
    bin = ""
    for i in range(len(s)):
        bin = bin + mp[s[i]]
    return bin
# Binary to hexadecimal conversion
def bin2hex(s):
    mp = {"0000": '0',
          "0001": '1',
          "0010": '2',
          "0011": '3',
          "0100": '4',
          "0101": '5',
          "0110": '6',
          "0111": '7',
          "1000": '8',
          "1001": '9',
          "1010": 'A',
          "1011": 'B',
          "1100": 'C',
```

```
          "1101": 'D',
          "1110": 'E',
          "1111": 'F'}
    hex = ""
    for i in range(0, len(s), 4):
        ch = ""
        ch = ch + s[i]
        ch = ch + s[i + 1]
        ch = ch + s[i + 2]
        ch = ch + s[i + 3]
        hex = hex + mp[ch]

    return hex
# Binary to decimal conversion


def bin2dec(binary):

    binary1 = binary
    decimal, i, n = 0, 0, 0
    while(binary != 0):
        dec = binary % 10
        decimal = decimal + dec * pow(2, i)
        binary = binary//10
        i += 1
```

```
    return decimal

# Decimal to binary conversion



def dec2bin(num):

    res = bin(num).replace("0b", "")

    if(len(res) % 4 != 0):

        div = len(res) / 4

        div = int(div)

        counter = (4 * (div + 1)) - len(res)

        for i in range(0, counter):

            res = '0' + res

    return res

# Permute function to rearrange the bits



def permute(k,k0, arr, n):

    permutation = ""

    for i in range(0, n):

        permutation = permutation + k[arr[i] - 1]
        permutation = permutation + k0[arr[i] - 1]
    return permutation


# shifting the bits towards left by nth shifts



def shift_left(k, nth_shifts):

    s = ""
```

```
    for i in range(nth_shifts):
        for j in range(1, len(k)):
            s = s + k[j]
        s = s + k[0]
        k = s
        s = ""
    return k
# calculating xor of two strings of binary number a and b


def xor(a, b):
    ans = ""
    for i in range(len(a)):
        if a[i] == b[i]:
            ans = ans + "0"
        else:
            ans = ans + "1"
    return ans

# Table of Position of 64 bits at initial level: Initial Permutation Table
initial_perm = [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]

# Expansion D-box Table

exp_d = [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]

# Straight Permutation Table

per = [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 Table

sbox = [[[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]],
```

```
[[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]],

[[10, 0, 9, 14, 6, 3, 15, 5, 1, 13, 12, 7, 11, 4, 2, 8],
 [13, 7, 0, 9, 3, 4, 6, 10, 2, 8, 5, 14, 12, 11, 15, 1],
 [13, 6, 4, 9, 8, 15, 3, 0, 11, 1, 2, 12, 5, 10, 14, 7],
 [1, 10, 13, 0, 6, 9, 8, 7, 4, 15, 14, 3, 11, 5, 2, 12]],

[[7, 13, 14, 3, 0, 6, 9, 10, 1, 2, 8, 5, 11, 12, 4, 15],
 [13, 8, 11, 5, 6, 15, 0, 3, 4, 7, 2, 12, 1, 10, 14, 9],
 [10, 6, 9, 0, 12, 11, 7, 13, 15, 1, 3, 14, 5, 2, 8, 4],
 [3, 15, 0, 6, 10, 1, 13, 8, 9, 4, 5, 11, 12, 7, 2, 14]],

[[2, 12, 4, 1, 7, 10, 11, 6, 8, 5, 3, 15, 13, 0, 14, 9],
 [14, 11, 2, 12, 4, 7, 13, 1, 5, 0, 15, 10, 3, 9, 8, 6],
 [4, 2, 1, 11, 10, 13, 7, 8, 15, 9, 12, 5, 6, 3, 0, 14],
 [11, 8, 12, 7, 1, 14, 2, 13, 6, 15, 0, 9, 10, 4, 5, 3]],

[[12, 1, 10, 15, 9, 2, 6, 8, 0, 13, 3, 4, 14, 7, 5, 11],
 [10, 15, 4, 2, 7, 12, 9, 5, 6, 1, 13, 14, 0, 11, 3, 8],
 [9, 14, 15, 5, 2, 8, 12, 3, 7, 0, 4, 10, 1, 13, 11, 6],
 [4, 3, 2, 12, 9, 5, 15, 10, 11, 14, 1, 7, 6, 0, 8, 13]],
```

```
        [[4, 11, 2, 14, 15, 0, 8, 13, 3, 12, 9, 7, 5, 10, 6, 1],
         [13, 0, 11, 7, 4, 9, 1, 10, 14, 3, 5, 12, 2, 15, 8, 6],
         [1, 4, 11, 13, 12, 3, 7, 14, 10, 15, 6, 8, 0, 5, 9, 2],
         [6, 11, 13, 8, 1, 4, 10, 7, 9, 5, 0, 15, 14, 2, 3, 12]],

        [[13, 2, 8, 4, 6, 15, 11, 1, 10, 9, 3, 14, 5, 0, 12, 7],
         [1, 15, 13, 8, 10, 3, 7, 4, 12, 5, 6, 11, 0, 14, 9, 2],
         [7, 11, 4, 1, 9, 12, 14, 2, 0, 6, 10, 13, 15, 3, 5, 8],
         [2, 1, 14, 7, 4, 10, 8, 13, 15, 12, 9, 0, 3, 5, 6, 11]]]
# Final Permutation Table
final_perm = [40, 8, 48, 16, 56, 24, 64, 32,
              39, 7, 47, 15, 55, 23, 63, 31,
              38, 6, 46, 14, 54, 22, 62, 30,
              37, 5, 45, 13, 53, 21, 61, 29,
              36, 4, 44, 12, 52, 20, 60, 28,
              35, 3, 43, 11, 51, 19, 59, 27,
              34, 2, 42, 10, 50, 18, 58, 26,
              33, 1, 41, 9, 49, 17, 57, 25]


def encrypt(pt, rkb, rk,text):
    pt = hex2bin(pt)
    text=rsa(text)
    # Initial Permutation
    pt = permute(pt, initial_perm, 64)
    text = permute(text, initial_perm, 64)
    print("After initial permutation", bin2hex(pt))
```

```
    print("After initial permutation", rsa(text))

    # Splitting

    left = pt[0:32]

    right = pt[32:64]

    left = text[0:32]

    right = text[32:64]

    for i in range(0, 16):

        #  Expansion D-box: Expanding the 32 bits data into 48 bits

        right_expanded = permute(right, exp_d, 48)


        # XOR RoundKey[i] and right_expanded

        xor_x = xor(right_expanded, rkb[i])


        # S-boxex: substituting the value from s-box table by calculating row
and column

        sbox_str = ""

        for j in range(0, 8):

            row = bin2dec(int(xor_x[j * 6] + xor_x[j * 6 + 5]))

            col = bin2dec(

                 int(xor_x[j * 6 + 1] + xor_x[j * 6 + 2] + xor_x[j * 6 + 3] +
xor_x[j * 6 + 4]))

            val = sbox[j][row][col]

            sbox_str = sbox_str + dec2bin(val)


        # Straight D-box: After substituting rearranging the bits

        sbox_str = permute(sbox_str, per, 32)
```

```
        # XOR left and sbox_str
        result = xor(left, sbox_str)
        left = result

        # Swapper
        if(i != 15):
            left, right = right, left
        print("Round ", i + 1, " ", bin2hex(left),
              " ", bin2hex(right), " ", rk[i])

    # Combination
    combine = left + right

    # Final permutation: final rearranging of bits to get cipher text
    cipher_text = permute(combine, final_perm, 64)
    return cipher_text


pt = "123456ABCD132536"
key = "AABB09182736CCDD"

# Key generation
# --hex to binary
key = hex2bin(key)
key0=rsa(key0)
# --parity bit drop table
keyp = [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]

# getting 56 bit key from 64 bit using the parity bits

key = permute(key, keyp, 56)
key0 = permute(key0, keyp, 56)
# Number of bit shifts

shift_table = [1, 1, 2, 2,

               2, 2, 2, 2,

               1, 2, 2, 2,

               2, 2, 2, 1]

# Key- Compression Table : Compression of key from 56 bits to 48 bits

key_comp = [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]

# Splitting
```

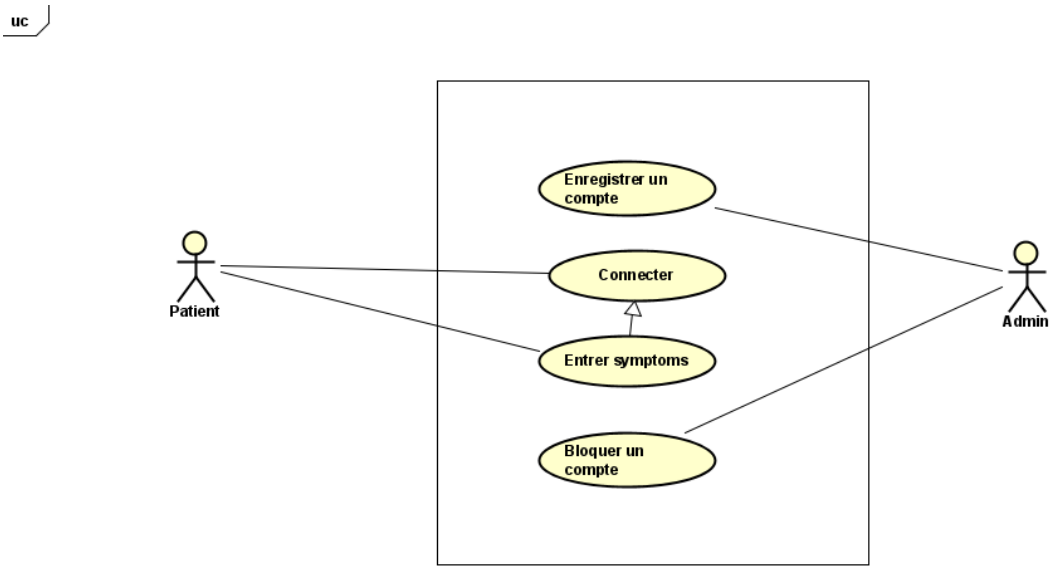
```
left = key[0:28]    # rkb for RoundKeys in binary

right = key[28:56]  # rk for RoundKeys in hexadecimal


rkb = []

rk = []

for i in range(0, 16):

    # Shifting the bits by nth shifts by checking from shift table

    left = shift_left(left, shift_table[i])

    right = shift_left(right, shift_table[i])


    # Combination of left and right string

    combine_str = left + right


    # Compression of key from 56 to 48 bits

    round_key = permute(combine_str, key_comp, 48)


    rkb.append(round_key)

    rk.append(bin2hex(round_key))

print("Encryption")

cipher_text = bin2hex(encrypt(pt, rkb, rk,text))

print("Cipher Text : ", cipher_text)

print("Decryption")

rkb_rev = rkb[::-1]

rk_rev = rk[::-1]

text = bin2hex(encrypt(cipher_text, rkb_rev, rk_rev))

print("Plain Text : ", text)
```

pour notre travail nous avons juste importé DES comme suit : `from Crypto.Cipher import DES`

III. SYSTEME

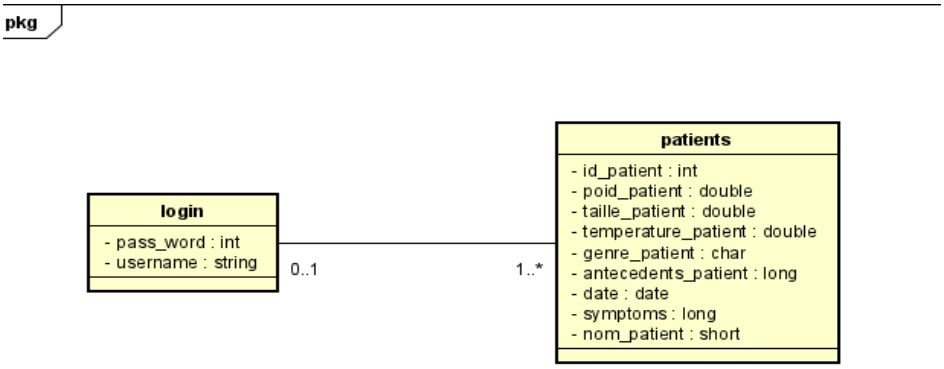
- Diagramme de cas d'utilisation

Dans ce projet notre diagramme de cas d'utilisation sera principalement composé d'un utilisateur principal et un utilisateur secondaire. Comme présenter dans le diagramme bellow, un utilisateur principal peut se connecter dans son compte, entrer les symptômes aussi et envoyer en fin la requête ; un utilisateur secondaire qui est l'admin du système peut enregistrer un patient et aussi il peut bloquer un utilisateur (un patient).

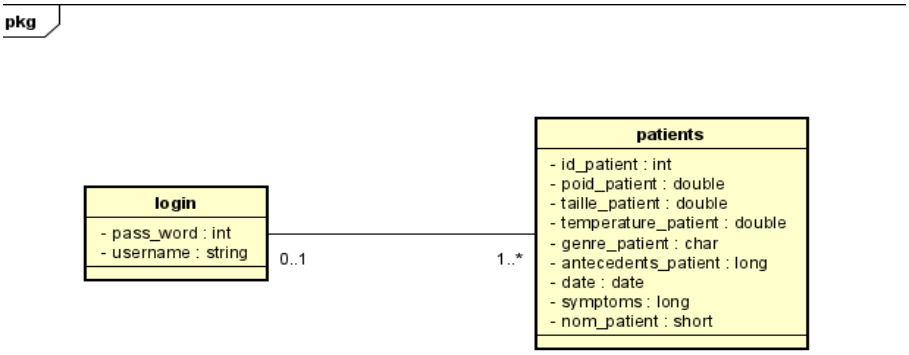


- Diagramme de classe

Pour ce projet avec sa version beta ; nous allons d'abord utiliser seulement deux classes principales dont la classe d'enregistrement de l'utilisateur et aussi la classe de patients avec toutes ses informations(symptômes) qu'il va envoyer pour avoir une prédiction des problèmes qu'il aurait dans son corps.



- Modèle relationnel



- Architecture de déploiement

L'architecture de déploiement de ce système serait à la base la mise ne place d'un réseau partagé localement d'abord pour une institution de santé et aussi un réseau Web pour permettre aux patients de se faire consulter en temps réel.

- Présentation de la solution

Les données médicales étant très sensible pour chaque patient ; la conservation de ces données et aussi la protection et la sécurité de ces données est de plus grande importance pour permettre aux patients de se faire consulter en toute sureté, confiance et sécurité ; ce travail a été spécifiquement réalisé dans le cadrer de mettre en place un système ou un algorithme de chiffrement de toutes les informations relatives à un patient pour permettre son anonymement et aussi la sécurité de ses informations.

Ainsi, la solution apportée sont les suivantes : la sécurité dans données médicales en ligne, la confiance des patient dans les logiciels de diagnostiques en ligne et l'amélioration des systèmes de E-Santé (Sante Electronique).

IV. CONCLUSION

In this work we had to encrypt medical data for a patient so that his or her information's should be in a security and we used DES encryption standard to realize that work.

In conclusion, the Data Encryption Standard (DES) is a block cipher with a 56-bit key length that has played a significant role in data security. However, due to vulnerabilities, its popularity has declined. DES operates through a series of rounds involving key transformation, expansion permutation, and substitution, ultimately producing ciphertext from plaintext. While DES has historical significance, it's crucial to consider more secure encryption alternatives for modern data protection needs.

Bibliographie

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