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22BCE3799

Cryptography and Network Security Lab Assessment 3

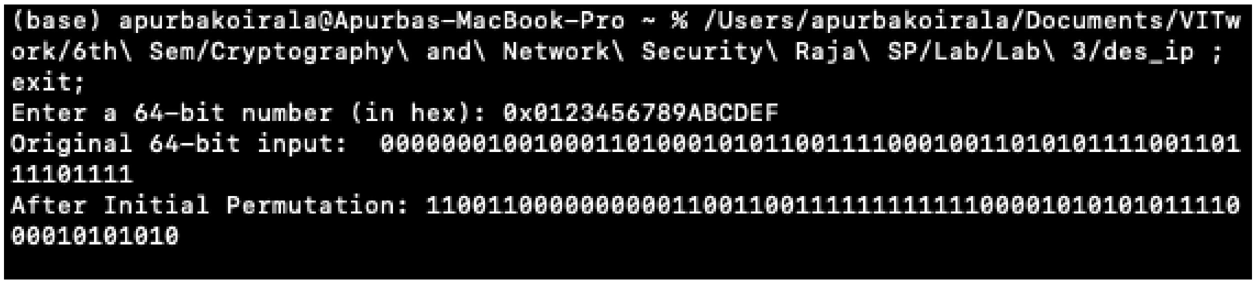
DES operations

3 a. To take input plaintext and perform initial permutation.

Code:

```
#include <iostream>
#include <bitset>
using namespace std;


int IP[] = {
    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
};


bitset<64> initialPermutation(bitset<64> input) {
    bitset<64> permuted;
    for (int i = 0; i < 64; i++) {
        permuted[63 - i] = input[64 - IP[i]];
    }
    return permuted;
}

int main() {
    uint64_t input;
    cout << "Enter a 64-bit number (in hex): ";
    cin >> hex >> input;

    bitset<64> inputBits(input);
    cout << "Original 64-bit input:  " << inputBits << endl;

    bitset<64> permutedBits = initialPermutation(inputBits);
    cout << "After Initial Permutation: " << permutedBits << endl;

    return 0;
}
```

Output:



```
(base) apurbakoirala@Apurbas-MacBook-Pro ~ % /Users/apurbakoirala/Documents/VITw
ork/6th\ Sem/Cryptography\ and\ Network\ Security\ Raja\ SP/Lab/Lab\ 3/des_ip ;
exit;
Enter a 64-bit number (in hex): 0x0123456789ABCDEF
Original 64-bit input:  00000001001000110100010101100111100010011010101111001101
11101111
After Initial Permutation: 11001100000000001100110011111111111100001010101011110
00010101010
```

3 b.

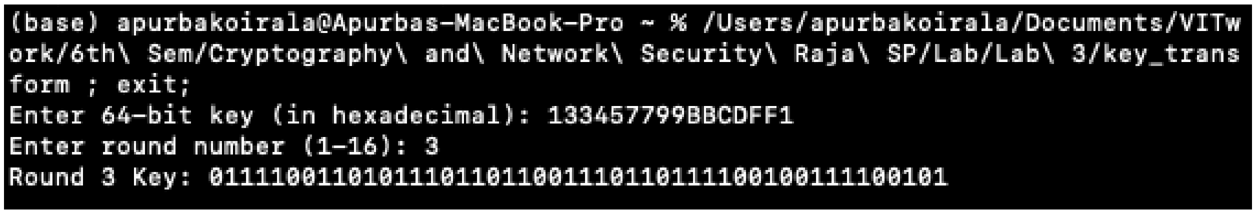
Key transformation from 64bits to 48bits including PC1, left circular shifts and PC2.

Code:

```
#include <iostream>
#include <bitset>
using namespace std;


int PC1[56] = {
    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
};

int PC2[48] = {
    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
};


int shiftSchedule[16] = {1, 1, 2, 2, 2, 2, 2, 2, 1, 2, 2, 2, 2, 2, 2, 1};


bitset<56> permutePC1(bitset<64> key) {
    bitset<56> permutedKey;
    for (int i = 0; i < 56; i++) {
        permutedKey[55 - i] = key[64 - PC1[i]];
    }
    return permutedKey;
}


bitset<48> permutePC2(bitset<56> combinedCD) {
    bitset<48> subKey;
    for (int i = 0; i < 48; i++) {
        subKey[47 - i] = combinedCD[56 - PC2[i]];
    }
    return subKey;
}

bitset<28> leftCircularShift(bitset<28> half, int shifts) {
    return (half << shifts) | (half >> (28 - shifts));
}
```

```cpp
int main() {
    uint64_t inputKey;
    int roundNumber;

    cout << "Enter 64-bit key (in hexadecimal): ";
    cin >> hex >> inputKey;
    cout << "Enter round number (1-16): ";
    cin >> roundNumber;

    if (roundNumber < 1 || roundNumber > 16) {
        cout << "Invalid round number. Must be between 1 and 16." << endl;
        return 1;
    }

    bitset<64> key(inputKey);
    bitset<56> permutedKey = permutePC1(key);


    bitset<28> C, D;
    for (int i = 0; i < 28; i++) {
        C[27 - i] = permutedKey[55 - i];
        D[27 - i] = permutedKey[27 - i];
    }



    int shifts = shiftSchedule[roundNumber - 1];
    C = leftCircularShift(C, shifts);
    D = leftCircularShift(D, shifts);

    bitset<56> combinedCD = (C.to_ullong() << 28) | D.to_ullong();



    bitset<48> roundKey = permutePC2(combinedCD);



    cout << "Round " << roundNumber << " Key: " << roundKey << endl;
    return 0;
}
```

Output:



```
(base) apurbakoirala@Apurbas-MacBook-Pro ~ % /Users/apurbakoirala/Documents/VITw
ork/6th\ Sem/Cryptography\ and\ Network\ Security\ Raja\ SP/Lab/Lab\ 3/key_trans
form ; exit;
Enter 64-bit key (in hexadecimal): 133457799BBCDFF1
Enter round number (1-16): 3
Round 3 Key: 011110011010111011011001110110111100100111100101
```

3 c.

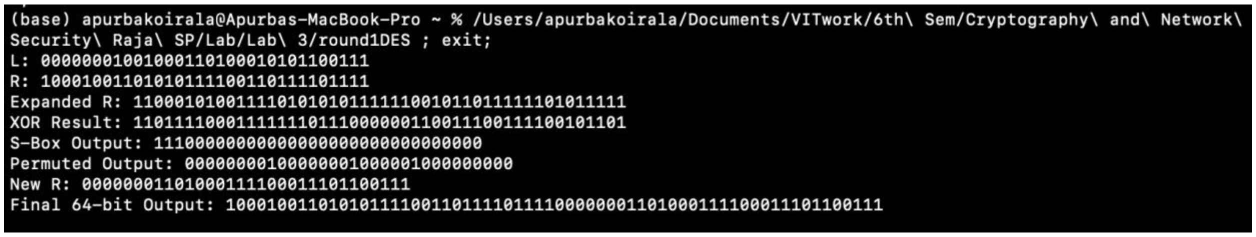
Round 1 operation with 64bit text after initial permutation and 48bit key after PC2

```
#include <iostream>
#include <bitset>
using namespace std;


int E[48] = {
   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
};


int SBox[8][4][16] = {

   {{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}},
};

int P[32] = {
   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
};


bitset<48> expand(bitset<32> R) {
   bitset<48> expanded;
   for (int i = 0; i < 48; i++) {
       expanded[47 - i] = R[32 - E[i]];
   }
   return expanded;
}


bitset<32> sBoxSubstitution(bitset<48> input) {
   bitset<32> output;
   for (int i = 0; i < 8; i++) {
       int row = (input[47 - (i * 6)] << 1) | input[47 - (i * 6 + 5)];
       int col = (input[47 - (i * 6 + 1)] << 3) | (input[47 - (i * 6 + 2)] << 2) |
                 (input[47 - (i * 6 + 3)] << 1) | input[47 - (i * 6 + 4)];
       int value = SBox[i][row][col];
       for (int j = 0; j < 4; j++) {
           output[31 - (i * 4 + j)] = (value >> (3 - j)) & 1;
       }
   }
   return output;
}


bitset<32> permute(bitset<32> input) {
   bitset<32> output;
   for (int i = 0; i < 32; i++) {
       output[31 - i] = input[32 - P[i]];
   }
   return output;
}

int main() {
```

```cpp
bitset<64> input("0000000100100011010001010110011110001001101010111100110111101111");
bitset<48> roundKey("000110110000001011101111111111000111000001110010");



bitset<32> L, R;
for (int i = 0; i < 32; i++) {
    L[i] = input[i + 32];
    R[i] = input[i];
}

bitset<48> expandedR = expand(R);

bitset<48> xorResult = expandedR ^ roundKey;

bitset<32> sBoxOutput = sBoxSubstitution(xorResult);

bitset<32> permutedOutput = permute(sBoxOutput);

bitset<32> newR = L ^ permutedOutput;
bitset<32> newL = R;

bitset<64> finalOutput;
for (int i = 0; i < 32; i++) {
    finalOutput[i + 32] = newL[i];
    finalOutput[i] = newR[i];
}

cout << "L: " << L << endl;
cout << "R: " << R << endl;
cout << "Expanded R: " << expandedR << endl;
cout << "XOR Result: " << xorResult << endl;
cout << "S-Box Output: " << sBoxOutput << endl;
cout << "Permuted Output: " << permutedOutput << endl;
cout << "New R: " << newR << endl;
cout << "Final 64-bit Output: " << finalOutput << endl;
```

```
    return 0;
}
```

Output:



```
(base) apurbakoirala@Apurbas-MacBook-Pro ~ % /Users/apurbakoirala/Documents/VITwork/6th\ Sem/Cryptography\ and\ Network\
Security\ Raja\ SP/Lab/Lab\ 3/round1DES ; exit;
L: 00000001001000110100010101100111
R: 10001001101010111100110111101111
Expanded R: 110001010011110101010111111001011011111101011111
XOR Result: 110111100011111101110000001100111001111100101101
S-Box Output: 11100000000000000000000000000000
Permuted Output: 00000000100000001000001000000000
New R: 00000001101000111100011101100111
Final 64-bit Output: 1000100110101011110011011110111100000001101000111100011101100111
```