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PRN No: 2020BTECS00041

Assignment No 3

Aim: To Study and implementation of Playfair Technique

Theory: It is classic symmetric-key encryption technique that operates on pairs of letters, making it more secure than simpler methods like the Caesar cipher. Here's how the Playfair cipher works:

Key Matrix: You start with a key, which is usually a word or phrase. This key is used to create a 5x5 matrix, known as the Playfair matrix, with unique letters from the key, followed by the remaining letters of the alphabet (excluding 'J').

Text Preparation: Remove any spaces and punctuation from the plaintext message. Also, combine double letters into one.

Encryption Rules:
For each pair of letters in the plaintext:
If letters are in same row, replace them with letters to their right cyclically
If letters are in same column, replace them with the letters below cyclically.
If letters are not in same row or column, form a rectangle with these letters and replace them with letters at opposite corners of rectangle.

Handling Odd Letters: If there are odd number of letters in plaintext (before pairing), can add a filler letter like 'X' at end.

Decryption: To decrypt, use same Playfair matrix and apply the reverse of encryption rules.

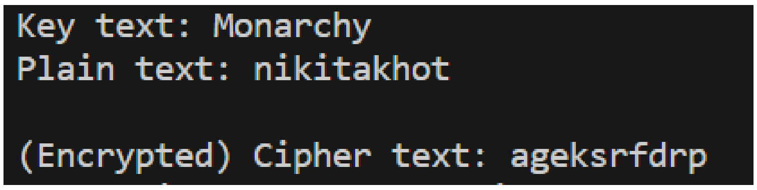
Encryption:

Code:

```
// Playfair Cipher
#include <bits/stdc++.h>
using namespace std;
#define SIZE 30

// Function to convert the string to lowercase
void toLowerCase(char plain[], int ps)
{
    int i;
    for (i = 0; i < ps; i++)
    {
        if (plain[i] > 64 && plain[i] < 91)
```

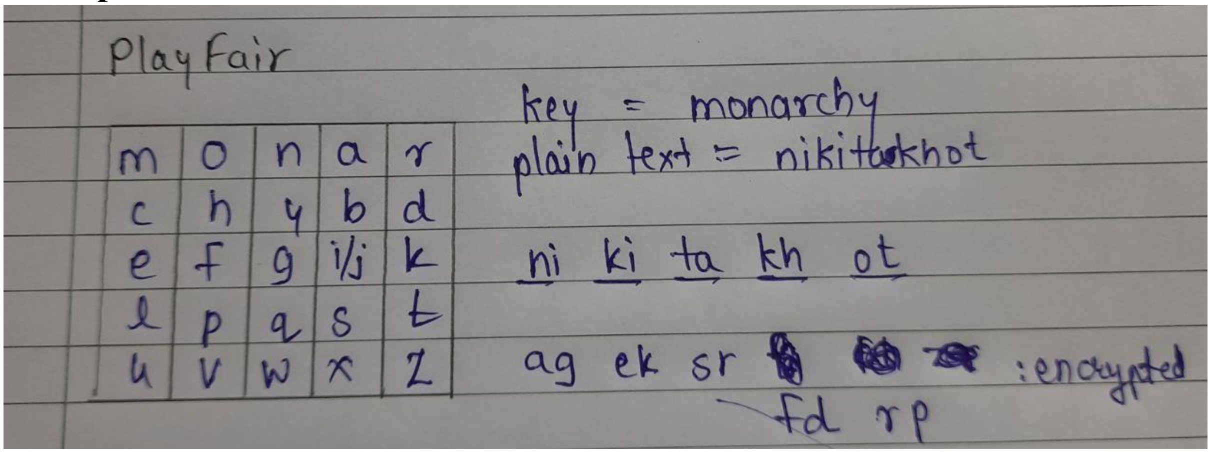
```c
            plain[i] += 32;
    }
}

// Function to remove all spaces in a string
int removeSpaces(char* plain, int ps)
{
    int i, count = 0;
    for (i = 0; i < ps; i++)
        if (plain[i] != ' ')
            plain[count++] = plain[i];
    plain[count] = '\0';
    return count;
}

// Function to generate the 5x5 key square
void generateKeyTable(char key[], int ks, char keyT[5][5])
{
    int i, j, k;
    // a 26 character hashmap
    // to store count of the alphabet
    int dicty[26] = { 0 };
    for (i = 0; i < ks; i++)
    {
        if (key[i] != 'j')
            dicty[key[i] - 97] = 2;
    }
    dicty['j' - 97] = 1;
    i = 0;
    j = 0;
    for (k = 0; k < ks; k++)
    {
        if (dicty[key[k] - 97] == 2)
        {
            dicty[key[k] - 97] -= 1;
            keyT[i][j] = key[k];
            j++;
            if (j == 5)
            {
                i++;
                j = 0;
            }
        }
    }
    for (k = 0; k < 26; k++)
    {
        if (dicty[k] == 0)
        {
            keyT[i][j] = (char)(k + 97);
            j++;
            if (j == 5)
            {
                i++;
                j = 0;
            }
        }
    }
}

// Function to search for the characters of a digraph
// in the key square and return their position
void search(char keyT[5][5], char a, char b, int arr[])
{
    int i, j;
    if (a == 'j')
        a = 'i';
    else if (b == 'j')
        b = 'i';
    for (i = 0; i < 5; i++)
    {
        for (j = 0; j < 5; j++)
        {
            if (keyT[i][j] == a)
            {
                arr[0] = i;
                arr[1] = j;
            }
            else if (keyT[i][j] == b)
            {
                arr[2] = i;
                arr[3] = j;
            }
        }
    }
}

// Function to find the modulus with 5
int mod5(int a) { return (a % 5); }

// Function to make the plain text length to be even
int prepare(char str[], int ptrs)
{
    if (ptrs % 2 != 0)
    {
        str[ptrs++] = 'z';
        str[ptrs] = '\0';
    }
    return ptrs;
}

// Function for performing the encryption
void encrypt(char str[], char keyT[5][5], int ps)
{
    int i, a[4];
    for (i = 0; i < ps; i += 2)
    {
        search(keyT, str[i], str[i + 1], a);
        if (a[0] == a[2])
        {
            str[i] = keyT[a[0]][mod5(a[1] + 1)];
            str[i + 1] = keyT[a[0]][mod5(a[3] + 1)];
        }
        else if (a[1] == a[3])
        {
            str[i] = keyT[mod5(a[0] + 1)][a[1]];
            str[i + 1] = keyT[mod5(a[2] + 1)][a[1]];
        }
        else
        {
            str[i] = keyT[a[0]][a[3]];
            str[i + 1] = keyT[a[2]][a[1]];
        }
    }
}

// Function to encrypt using Playfair Cipher
void encryptByPlayfairCipher(char str[], char key[])
{
    char ps, ks, keyT[5][5];
    // Key
    ks = strlen(key);
    ks = removeSpaces(key, ks);
    toLowerCase(key, ks);
    // Plaintext
    ps = strlen(str);
    toLowerCase(str, ps);
    ps = removeSpaces(str, ps);
    ps = prepare(str, ps);
    generateKeyTable(key, ks, keyT);
    encrypt(str, keyT, ps);
}

// Driver code
int main()
{
    char str[30], key[30];
    strcpy(key, "Monarchy");
    cout << "Key text: " << key << "\n";
    strcpy(str, "nikitakhot");
    cout << "Plain text: " << str << "\n";
    encryptByPlayfairCipher(str, key);
    cout << "\n(Encrypted) Cipher text: " << str << "\n";
    return 0;
}
```

Output:



```
Key text: Monarchy
Plain text: nikitakhot

(Encrypted) Cipher text: ageksrfdrp
```

Example:



Play Fair

m	o	n	a	r
c	h	y	b	d
e	f	g	i/j	k
l	p	q	s	t
u	v	w	x	z

key = monarchy
plain text = nikitakhot

ni ki ta kh ot

ag ek sr :encrypted
fd rp

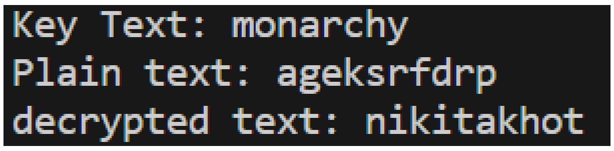
Decryption:

Code:

```
#include <bits/stdc++.h>
using namespace std;
#define SIZE 30
```

```c
void toLowerCase(char plain[], int ps)
{
    int i;
    for (i = 0; i < ps; i++) {
        if (plain[i] > 64 && plain[i] < 91)
            plain[i] += 32;
    }
}

int removeSpaces(char* plain, int ps)
{
    int i, count = 0;
    for (i = 0; i < ps; i++)
        if (plain[i] != ' ')
            plain[count++] = plain[i];
    plain[count] = '\0';
    return count;
}

// generates the 5x5 key square
void generateKeyTable(char key[], int ks, char keyT[5][5])
{
    int i, j, k, *dicty;

    dicty = (int*)calloc(26, sizeof(int));

    for (i = 0; i < ks; i++) {
        if (key[i] != 'j')
            dicty[key[i] - 97] = 2;
    }
    dicty['j' - 97] = 1;

    i = 0;
    j = 0;
    for (k = 0; k < ks; k++) {
        if (dicty[key[k] - 97] == 2) {
            dicty[key[k] - 97] -= 1;
            keyT[i][j] = key[k];
            j++;
            if (j == 5) {
                i++;
                j = 0;
            }
        }
    }
    for (k = 0; k < 26; k++) {
        if (dicty[k] == 0) {
            keyT[i][j] = (char)(k + 97);
            j++;
            if (j == 5) {
                i++;
                j = 0;
            }
        }
    }
}

void search(char keyT[5][5], char a, char b, int arr[])
{
    int i, j;

    if (a == 'j')
        a = 'i';
    else if (b == 'j')
        b = 'i';

    for (i = 0; i < 5; i++) {
        for (j = 0; j < 5; j++) {
            if (keyT[i][j] == a) {
                arr[0] = i;
                arr[1] = j;
            }
            else if (keyT[i][j] == b) {
                arr[2] = i;
                arr[3] = j;
            }
        }
    }
}

int mod5(int a)
{
    if (a < 0)
        a += 5;
    return (a % 5);
}

void decrypt(char str[], char keyT[5][5], int ps)
{
    int i, a[4];
    for (i = 0; i < ps; i += 2) {
        search(keyT, str[i], str[i + 1], a);
        if (a[0] == a[2]) {
            str[i] = keyT[a[0]][mod5(a[1] - 1)];
            str[i + 1] = keyT[a[0]][mod5(a[3] - 1)];
        }
        else if (a[1] == a[3]) {
            str[i] = keyT[mod5(a[0] - 1)][a[1]];
            str[i + 1] = keyT[mod5(a[2] - 1)][a[1]];
        }
        else {
            str[i] = keyT[a[0]][a[3]];
            str[i + 1] = keyT[a[2]][a[1]];
        }
    }
}

void decryptByPlayfairCipher(char str[], char key[])
{
    char ps, ks, keyT[5][5];

    // Key
    ks = strlen(key);
    ks = removeSpaces(key, ks);
    toLowerCase(key, ks);
    // ciphertext
    ps = strlen(str);
    toLowerCase(str, ps);
    ps = removeSpaces(str, ps);
    generateKeyTable(key, ks, keyT);
    decrypt(str, keyT, ps);
}

int main()
{
    char str[SIZE], key[SIZE];
    strcpy(key, "Monarchy");
    cout << "Key Text: " << key << endl;
    strcpy(str, "ageksrfdrp");
    cout << "Plain text: " << str << endl;
    decryptByPlayfairCipher(str, key);
    cout << "Deciphered text: " << str << endl;
    return 0;
}
```

Output:



```
Key Text: monarchy
Plain text: ageksrfdrp
decrypted text: nikitakhot
```

Limitations:

The Playfair cipher provides a good level of security for its simplicity, but it's not as strong as modern encryption methods.