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Implementation & Comparative Analysis of RSA, Caesar Cipher and Playfair Cipher

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Abstract: With the growing use of the Internet, and more people being connected with it, the security of the data becomes a major concern. It is necessary that the data can only be accessed by the intended receiver and no person in the middle makes alterations to it. This is achieved by encryption of the data using cryptography.

This paper presents a comparative analysis of RSA (Rivest-Shamir-Adleman), Caesar Cipher and Playfair Cipher cryptographic techniques. This paper also presents a comparative analysis of Symmetric Key Cryptography and Asymmetric Key Cryptography. Also, this paper includes the basic working of the above-mentioned techniques along with their implementation in C language over Visual Studio Code 1.49.3.

Keywords: Cryptography, encryption, decryption, symmetric key cryptography, asymmetric cryptography, RSA (Rivest-Shamir-Adleman), Caesar Cipher, Playfair Cipher.

I. INTRODUCTION

Cryptography is basically the art of encrypting data in order to enhance security. This is done by converting the data into codes using a key, which can then be decrypted at the receiving end using the same key or a different key, depending upon the algorithm used. A very vital part of secure communication is to maintain the integrity and privacy of data which can be achieved by cryptography.

Cryptography is primarily performed by applying algorithms on the given data for its secure transmission and storage. Cryptographic algorithms are basically techniques which are derived from mathematical concepts and contain a set of calculations to be performed on the data, and convert it into a code, so that it becomes difficult to understand for anyone in case there is a security breach. The receiver on the other end can decode the data using the algorithm used to encode the data, and thus use and modify the data as per need.

A. Basic Terms used in Cryptography

- 1) **Plain Text:** The original data or text is known as plain text.
- 2) **Cipher Text:** The data or text obtained after applying a cryptographic algorithm on the plain text. Cipher text is meaningless and unreadable.
- 3) **Encryption:** The process of converting Plaintext to Cipher Text is known as encryption.
- 4) **Decryption:** The process of converting Ciphertext to Plain Text is known as decryption.
- 5) **Cryptanalysis:** It is the study of techniques or methods to get the meaning of the encrypted data or text.
- 6) **Key:** A key is a combination of numeric or alpha-numeric characters. It takes place on the plain text in the process of encryption and on the cipher text in case of decryption.
- 7) **Key-Size:** It is the measure of length of the key used in any algorithm. It is measured in bits.
- 8) **Round:** Round of encryption means how much time the encryption function is executed in the whole process of encryption till it gives cipher text as output.

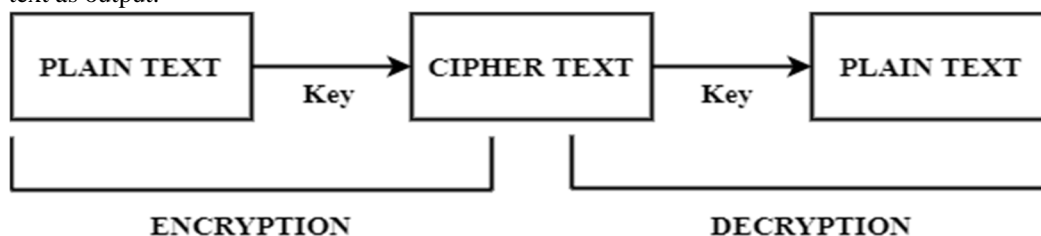


Figure 1: Basic flowchart of cryptography

B. Main objectives of Cryptography

The main goals of cryptography are:

- 1) *Authentication*: As per this property, both the sender and the receiver can confirm each other's identity, origin and destination of the data.
- 2) *Confidentiality*: This means that the main information can only be understood and altered by only the people who are authorized/intended to use the data.
- 3) *Integrity*: This means that the information should not be altered or changed while transferring or while in storage. The receiver must receive the exact data sent by the creator/sender.
- 4) *Non-repudiation*: According to this the original creator/sender of the data cannot deny his or her intention in the creation or transfer of data, at a later stage.

II. TYPES OF CRYPTOGRAPHIC ALGORITHMS

There are mainly 2 types of cryptographic algorithms:

- A. Symmetric cryptographic algorithms, also known as private key cryptography, involves a single key for both encryption and decryption purposes on the sender and receiver side. This key is kept private between both of them so that no data is stolen by an attacker while the transfer or storing of data.
- B. Asymmetric cryptographic algorithms, also known as public key cryptography, consists of a key pair for encryption and decryption of data. The key pair is composed of a private key and a public key. If the data is encrypted using the public key then decryption will be done with the private key and vice-versa.

Thus, asymmetric key encryption is more secure, however, symmetric key cryptography is faster in terms of encryption speed.

III. SYMMETRIC KEY CRYPTOGRAPHY Vs ASYMMETRIC KEY CRYPTOGRAPHY

Table 1: Difference between Symmetric and Asymmetric Key Cryptography

SYMMETRIC KEY CRYPTOGRAPHY	ASYMMETRIC KEY CRYPTOGRAPHY
The same key, known as the private key is used for both the encryption and decryption of the data.	In this, a key pair is involved, consisting of a private key and a public key. If one key is used for encryption then the other key will be used for the decryption.
Its encryption/decryption speed is very fast.	It is comparatively slower than symmetric key cryptography.
The size of the encrypted text is usually the same or less than that of the original text.	The size of the encrypted data is usually more than that of the original text.
The process is quite simple as only one key is used in both the operations.	The process is quite complex as separate keys are used for both the operations.
This type of cryptography is mostly done in modern computer systems to protect the privacy of the user and improve the security.	This type of cryptography is used mainly for sharing information or data between different organizations and to secure online transactions.
Some common examples of symmetric key cryptography are: <ol style="list-style-type: none"> 1. RC4, 2. AES, 3. DES, 3DES. 	Some common examples of asymmetric key cryptography are: <ol style="list-style-type: none"> 1. Diffie-Hellman, 2. RSA, 3. ECC.

There are various ways developed to perform the encryption and decryption of the data. Our main focus will be RSA, Caesar Cipher and Playfair Cipher.

IV. WORKING OF RSA (RIVEST-SHAMIR-ADLEMAN)

RSA is a public key cryptographic algorithm, named after the surnames of its designers, Ron Rivest, Adi Shamir and Leonard Adleman. This algorithm was described publicly by its designers in 1977. It is an asymmetric key cryptosystem which is mainly used for secure data transmission. The RSA algorithm relies widely on the practical difficulty of factoring the product of two large prime numbers, making it a quite secure algorithm. However, it is a slow algorithm and is not commonly used to directly encrypt the data.

A. Steps of encrypting and decrypting data in RSA

1) Select two numbers p and q , such that, p and q are not equal, and are prime numbers.

2) Calculate the value of n as:

$$n = pq$$

3) Calculate $\Phi(n)$ as

$$\Phi(n) = (p-1)(q-1)$$

4) Select an integer e , such that $\gcd(\Phi(n), e) = 1$ and $1 < e < \Phi(n)$.

5) The value of d is calculated using the formula

$$d = e^{-1} \pmod{\Phi(n)}$$

6) Public Key is given as $= \{ e, n \}$.

7) Private Key is given as $= \{ d, n \}$.

B. Encryption Process

1) Consider the plain text, M .

2) The cipher text, C will be given as

$$C = M^e \pmod{n}$$

C. Decryption Process

1) Consider the cipher text, C .

2) The plain text, M will be given as

$$M = C^d \pmod{n}$$

V. WORKING OF CAESAR CIPHER

Caesar Cipher is an example of symmetric key cryptography. It is one of the most early and simple forms of encryption. It is a type of substitution cipher, in which each letter of the text is replaced by a letter which is some fixed position down the alphabet. For example – with a shift of five, A would become F, B would become G and so on. Shift is basically just an integer value that indicates the number of positions each letter has to be moved.

The process can be represented using the modular arithmetic as follows:

1) Transform the letters into numbers using the scheme, $A=0, B=1, \dots, Y=24$ and $Z=25$.

2) Consider the value of shift as n , the value of Cipher text as C and the value of Plain text as M then:

Encryption would be done using the formula, $C = (M + n) \pmod{26}$.

Decryption would be done using the formula, $M = (C - n) \pmod{26}$.

VI. WORKING OF PLAYFAIR CIPHER

Playfair Cipher is a type of symmetric key cryptography and is the first practical digraph substitution cipher. This technique encrypts a set of letters instead of a single letter (as in the case of Caesar Cipher). The Playfair cipher uses a 5 by 5 table containing the word or the phrase which needs to be encrypted.

A. Steps

1) A key square is to be generated, which is a 5x5 matrix, consisting of the alphabets that act as the key for encrypting the plaintext. All the 25 elements for the matrix must be unique and usually the letter J is omitted from the table (as there are only 25 cells). If the plaintext contains J it is replaced by I. The initial alphabets in the key square are the unique alphabets in the key square are the unique alphabets of the key.

2) The plain text is divided into pairs of two letters called digraphs. If the number of letters is odd, then Z is added to the last letter.

B. Encryption Process

- 1) If both the letters are in the same column, take the letter below each one.
- 2) If both the letters are present in the same row then pick the letter to the right of each one.
- 3) If none of the above rules is true, then form a rectangle with the two letters and consider the letters which are on the horizontal opposite corner of the rectangle.

VII. IMPLEMENTATION OF RSA (RIVEST-SHAMIR-ADLEMAN)

```

1  /* This program is for the implementation of RSA asymmetric key algorithm in which
2  the user only will input the encryption key and also the message to be encrypted. */
3  /* Note :- This code is just a picture of how actual RSA works.
4  Actual RSA does not functions on such small values. This is just an example to show. */
5
6  #include<stdio.h>
7  #include<math.h>
8
9  //to find Greatest Common Divisor, gcd
10 int gcd(int a, int h)
11 {
12     int temp;
13     while(1)
14     {
15         temp = a%h;
16         if(temp==0)
17             return h;
18         a = h;
19         h = temp;
20     }
21 }
22
23 int main()
24 {
25     //inputting two random prime numbers
26     double p;
27     printf("enter the first random prime number (p) = ");
28     scanf("%lf", &p);
29     double q;
30     printf("enter the second random prime number (q) = ");
31     scanf("%lf", &q);
32     double n = p*q;
33     printf("calculated n = %lf", n);
34     double count;
35     double totient = (p-1)*(q-1);
36     printf("uncalculated totient = %lf", totient);
37
38     //public key inputted by the user
39     //e stands for encryption key
40     double e;
41     printf("\n enter encryption key = ");
42     scanf("%lf", &e);
43
44     //for checking whether the inputted encryption key is a co-prime or not.
45     if co-prime it will satisfy the condition e!%totient
46     while(e%totient){
47         count = gcd(e,totient);
48         if(count==1)
49             break;
50     }

```

Figure 2(a)

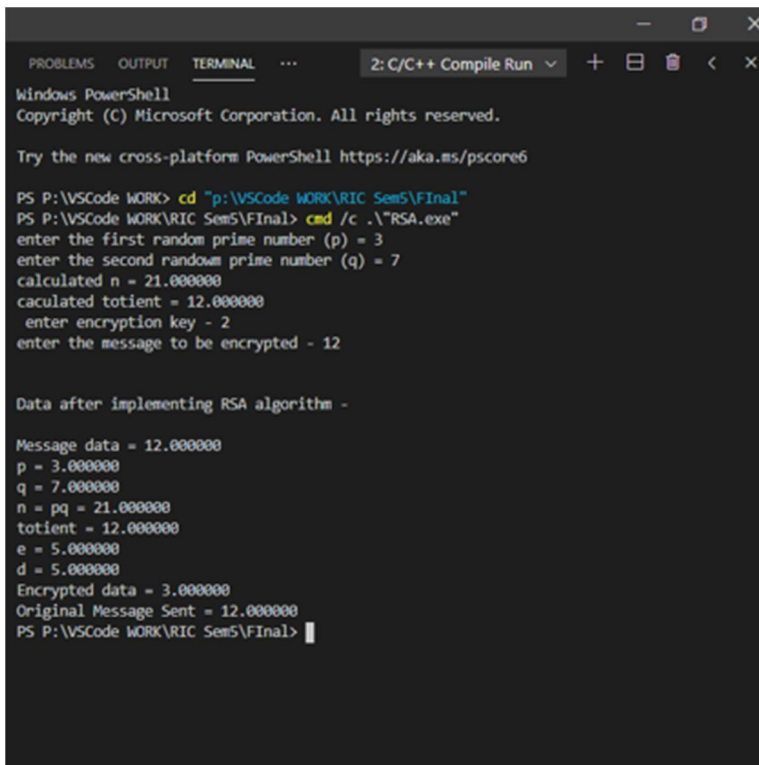
```

38     //public key inputted by the user
39     //e stands for encryption key
40     double e;
41     printf("\n enter encryption key = ");
42     scanf("%lf", &e);
43
44     //for checking whether the inputted encryption key is a co-prime or not.
45     if co-prime it will satisfy the condition e!%totient
46     while(e%totient){
47         count = gcd(e,totient);
48         if(count==1)
49             break;
50     }
51     else
52         e++;
53
54     //private key which is calculated using the earlier inputted 2 random prime numbers
55     //d stands for decryption key
56     double d;
57
58     //k can be any arbitrary value
59     double k = 2;
60
61     //choosing d, the decryption key such that it satisfies d*e = 1 + k * totient
62     d = (1 + (k*totient))/e;
63     double msg;
64     printf("enter the message to be encrypted = ");
65     scanf("%lf", &msg);
66     //pow is the library function, power or say exponents
67     double c = pow(msg,e);
68     double m = pow(c,d);
69     //fmod is the library function, floating modulus function
70     c=fmod(c,n);
71     m=fmod(m,n);
72
73     printf("\n\nData after implementing RSA algorithm - ");
74     printf("\n\nMessage data = %lf",msg);
75     printf("\n\np = %lf",p);
76     printf("\n\nq = %lf",q);
77     printf("\n\npq = %lf",n);
78     printf("\n\ntotient = %lf",totient);
79     printf("\n\n e = %lf",e);
80     printf("\n\n d = %lf",d);
81     printf("\n\nEncrypted data = %lf",c);
82     printf("\n\nOriginal Message Sent = %lf",m);
83
84     return 0;
85 }

```

Figure 2(b)

Figure 2(a) and 2(b) Source code of RSA (Rivest-Shamir-Adleman)



```

PROBLEMS OUTPUT TERMINAL ... 2: C/C++ Compile Run
Windows PowerShell
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PS P:\VSCode WORK> cd "p:\VSCode WORK\RIC Sem5\Final"
PS P:\VSCode WORK\RIC Sem5\Final> cmd /c .\RSA.exe
enter the first random prime number (p) = 3
enter the second random prime number (q) = 7
calculated n = 21.000000
calculated totient = 12.000000
enter encryption key - 2
enter the message to be encrypted - 12

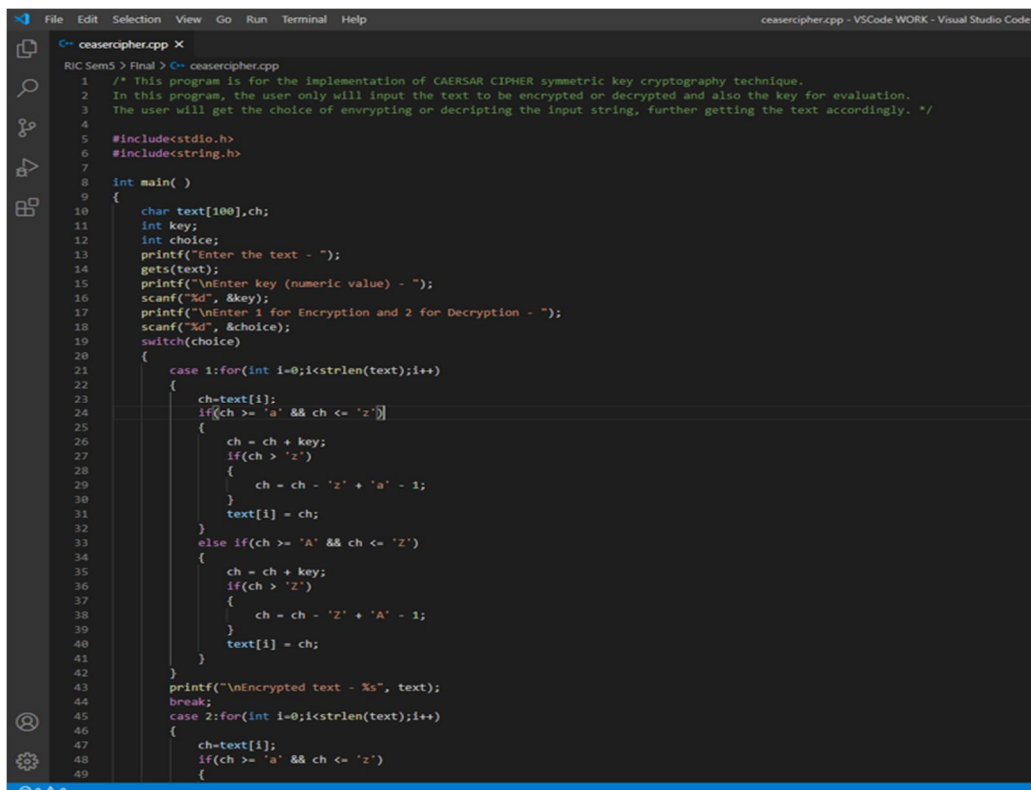
Data after implementing RSA algorithm -

Message data = 12.000000
p = 3.000000
q = 7.000000
n = pq = 21.000000
totient = 12.000000
e = 5.000000
d = 5.000000
Encrypted data = 3.000000
Original Message Sent = 12.000000
PS P:\VSCode WORK\RIC Sem5\Final>

```

Figure 3. Output of RSA (Rivest-Shamir-Adleman)

VIII. IMPLEMENTATION OF CAESAR CIPHER



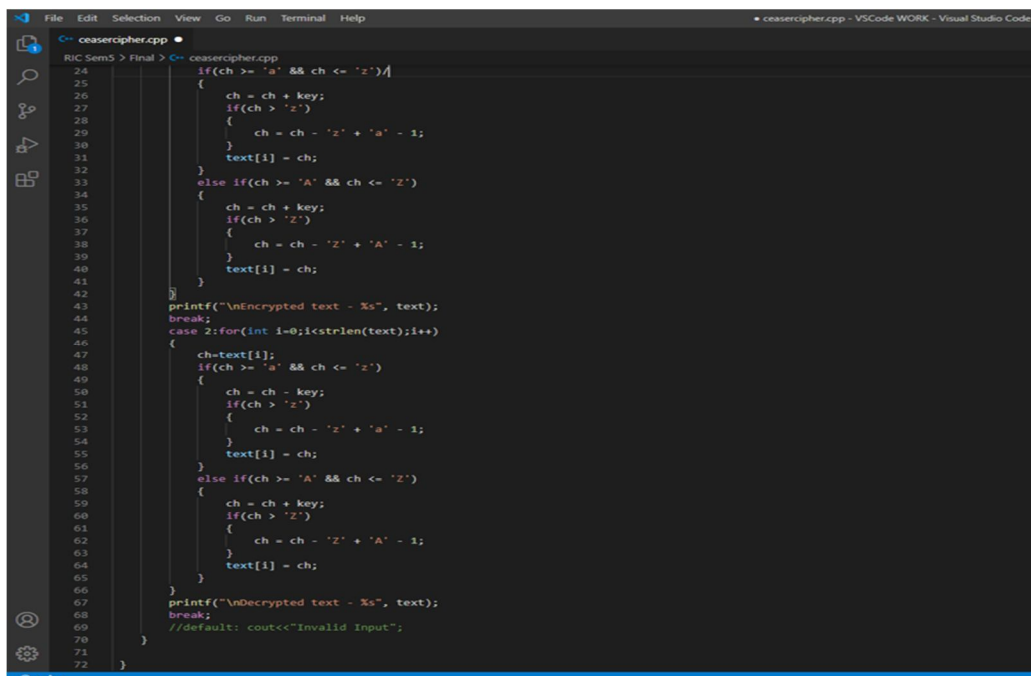
```

File Edit Selection View Go Run Terminal Help
caesarcipher.cpp - VSCode WORK - Visual Studio Code

C++ caesarcipher.cpp
RIC Sem5 > Final > C++ caesarcipher.cpp
1 /* This program is for the implementation of CAESAR CIPHER symmetric key cryptography technique.
2 In this program, the user only will input the text to be encrypted or decrypted and also the key for evaluation.
3 The user will get the choice of encrypting or decrypting the input string, further getting the text accordingly. */
4
5 #include<stdio.h>
6 #include<string.h>
7
8 int main( )
9 {
10     char text[100],ch;
11     int key;
12     int choice;
13     printf("Enter the text - ");
14     gets(text);
15     printf("\nEnter key (numeric value) - ");
16     scanf("%d", &key);
17     printf("\nEnter 1 for Encryption and 2 for Decryption - ");
18     scanf("%d", &choice);
19     switch(choice)
20     {
21         case 1:for(int i=0;i<strlen(text);i++)
22         {
23             ch=text[i];
24             if(ch >= 'a' && ch <= 'z')
25             {
26                 ch = ch + key;
27                 if(ch > 'z')
28                 {
29                     ch = ch - 'z' + 'a' - 1;
30                 }
31                 text[i] = ch;
32             }
33             else if(ch >= 'A' && ch <= 'Z')
34             {
35                 ch = ch + key;
36                 if(ch > 'Z')
37                 {
38                     ch = ch - 'Z' + 'A' - 1;
39                 }
40                 text[i] = ch;
41             }
42         }
43         printf("\nEncrypted text - %s", text);
44         break;
45         case 2:for(int i=0;i<strlen(text);i++)
46         {
47             ch=text[i];
48             if(ch >= 'a' && ch <= 'z')
49             {

```

Figure 4(a)



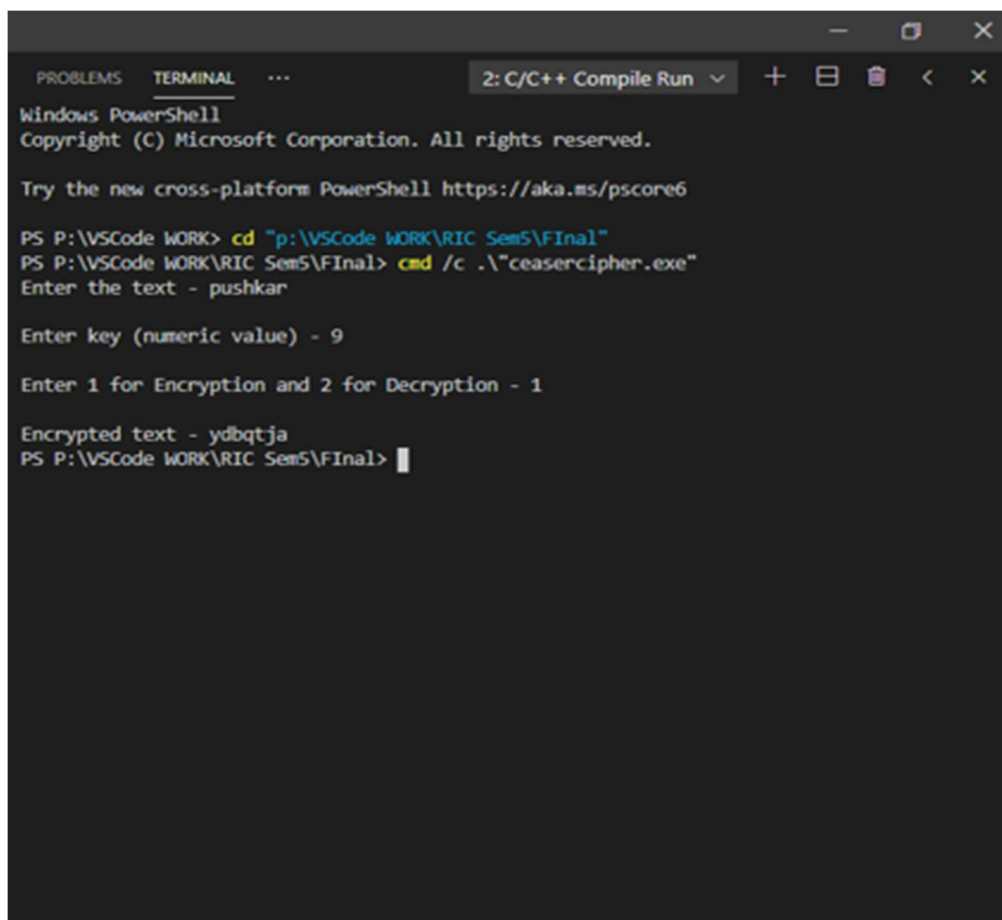
```

24  if(ch >= 'a' && ch <= 'z'){
25      {
26          ch = ch + key;
27          if(ch > 'z')
28          {
29              ch = ch - 'z' + 'a' - 1;
30          }
31          text[i] = ch;
32      }
33      else if(ch >= 'A' && ch <= 'Z')
34      {
35          ch = ch + key;
36          if(ch > 'Z')
37          {
38              ch = ch - 'Z' + 'A' - 1;
39          }
40          text[i] = ch;
41      }
42  }
43  printf("\nEncrypted text - %s", text);
44  break;
45  case 2:for(int i=0;i<strlen(text);i++)
46  {
47      ch=text[i];
48      if(ch >= 'a' && ch <= 'z')
49      {
50          ch = ch - key;
51          if(ch < 'a')
52          {
53              ch = ch - 'a' + 'z' + 1;
54          }
55          text[i] = ch;
56      }
57      else if(ch >= 'A' && ch <= 'Z')
58      {
59          ch = ch - key;
60          if(ch < 'A')
61          {
62              ch = ch - 'Z' + 'A' + 1;
63          }
64          text[i] = ch;
65      }
66  }
67  printf("\nDecrypted text - %s", text);
68  break;
69  //default: cout<<"Invalid Input";
70  }
71  }
72  }

```

Figure 4(b)

Figure 4(a) and 4(b) Source code of Caesar Cipher



```

2: C/C++ Compile Run
Windows PowerShell
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Try the new cross-platform PowerShell https://aka.ms/pscore6

PS P:\VSCode WORK\RIC Sem5\Final> cd "p:\VSCode WORK\RIC Sem5\Final"
PS P:\VSCode WORK\RIC Sem5\Final> cmd /c .\caesercipher.exe
Enter the text - pushkar

Enter key (numeric value) - 9

Enter 1 for Encryption and 2 for Decryption - 1

Encrypted text - ydbqtja
PS P:\VSCode WORK\RIC Sem5\Final>

```

Figure 5. Output of Caesar Cipher

IX. IMPLEMENTATION OF PLAYFAIR CIPHER

```

playfair.cpp - VSCode WORK - Visual Studio Code
C++ playfair.cpp X
RIC Sem5 > Final > C++ playfair.cpp
1  /* This program is for the implementation of PLAYFAIR CIPHER symmetric key cryptography technique.
2  In this program, the user only will input the string to be encrypted and also the text key for evaluation.
3  The user will get the formed matrix and the Cipher Text (encrypted text) as the output.*/
4
5  #include<stdio.h>
6  #include<string.h>
7  #include<ctype.h>
8  int removeRepeated(int size,int a[]);
9  int insertElementat(int position,int a[],int size);
10 main()
11 {
12     int i,j,k,numstr[100],numcipher[100],numkey[100],lenkey,templen,tempkey[100],flag=-1,size,cipherkey[5][5],lennumstr,row1,row2,col1,col2;
13     char str[100],key[100];
14     printf("Enter a string - ");
15     gets(str);
16     //converting entered string to Capital letters
17     for(i=0,j=0;i<strlen(str);i++)
18     {
19         if(str[i]!=' ')
20         {
21             str[j]=toupper(str[i]);
22             j++;
23         }
24     }
25     str[j]='\0';
26     printf("Entered String in upper case is - %s",str);
27     //Storing string in terms of ascii and to restore spaces I used - 20
28     size=strlen(str);
29     for(i=0;i<size;i++)
30     {
31         if(str[i]!=' ')
32             numstr[i]=str[i]-'A';
33     }
34     lennumstr=i;
35     //Key processing
36     printf("\nEnter the key (Non repeated elements if possible) - ");
37     gets(key);
38     //converting entered key to Capital letters
39     for(i=0,j=0;i<strlen(key);i++)
40     {
41         if(key[i]!=' ')
42         {
43             key[j]=toupper(key[i]);
44             j++;
45         }
46     }
47     key[j]='\0';
48     printf("Entered text key in upper case - %s",key);
49     //Storing key in terms of ascii

```

Figure 6(a)

```

playfair.cpp - VSCode WORK - Visual Studio Code
C++ playfair.cpp X
RIC Sem5 > Final > C++ playfair.cpp
40     printf("Entered text key in upper case - %s",key);
41     //Storing key in terms of ascii
42     k=0;
43     for(i=0;i<strlen(key)+26;i++)
44     {
45         if(i<strlen(key))
46         {
47             if(key[i]!='J')
48             {
49                 flag=0;
50                 printf("%d",flag);
51             }
52             numkey[i]=key[i]-'A';
53         }
54         else
55         {
56             if(k%26==0 && k!=flag)//Considering I=J and taking I in place of J except when J is there in key ignoring I
57             {
58                 numkey[i]=k;
59             }
60             k++;
61         }
62     }
63     templen=i;
64     lenkey=removeRepeated(templen,numkey);
65     printf("\nEnter key converted according to Play Fair Cipher rule (non matrix format) - \n");
66     for(i=0;i<lenkey;i++)
67     {
68         printf("%c",numkey[i]+'A');
69     }
70     printf("\n");
71     //Arranging the key in 5x5 grid
72     k=0;
73     for(i=0;i<5;i++)
74     {
75         for(j=0;j<5;j++)
76         {
77             cipherkey[i][j]=numkey[k];
78             k++;
79         }
80     }
81     printf("\nArranged key (in matrix format) - \n");
82     for(i=0;i<5;i++)
83     {
84         for(j=0;j<5;j++)
85         {
86             printf("%c ",cipherkey[i][j]+'A');
87         }
88         printf("\n");
89     }

```

Figure 6(b)


```

File Edit Selection View Go Run Terminal Help
playfair.cpp - VSCode WORK - Visual Studio Code

C++ playfair.cpp x
RIC Sem5 > Final > C++ playfair.cpp
96     printf("\n");
97 }
98 //Message Processing
99 for(i=0;i<lennumstr;i+=2)
100 {
101     if(numstr[i]==numstr[i+1])
102     {
103         insertelementat(i+1,numstr,lennumstr);
104         lennumstr++;
105     }
106 }
107 if(lennumstr%2!=0)
108 {
109     insertelementat(lennumstr,numstr,lennumstr);
110     lennumstr++;
111 }
112 printf("\nEnter string for Processing according to Play fair cipher rule - ");
113 for(i=0;i<lennumstr;i++)
114 {
115     printf("%c",numstr[i]+'A');
116 }
117 for(k=0;k<lennumstr;k+=2)
118 {
119     for(i=0;i<5;i++)
120     {
121         for(j=0;j<5;j++)
122         {
123             if(numstr[k]==cipherkey[i][j])
124             {
125                 row1=i;
126                 col1=j;
127             }
128             if(numstr[k+1]==cipherkey[i][j])
129             {
130                 row2=i;
131                 col2=j;
132             }
133         }
134     }
135     //Only change between Encryption to decryption is changing + to -
136     //If negative add 5 to that row or column
137     if(row1==row2)
138     {
139         col1=(col1-1)%5;
140         col2=(col2-1)%5;
141         if(col1<0)
142         {
143             col1=5+col1;
144         }
145     }

```

Figure 6(c)

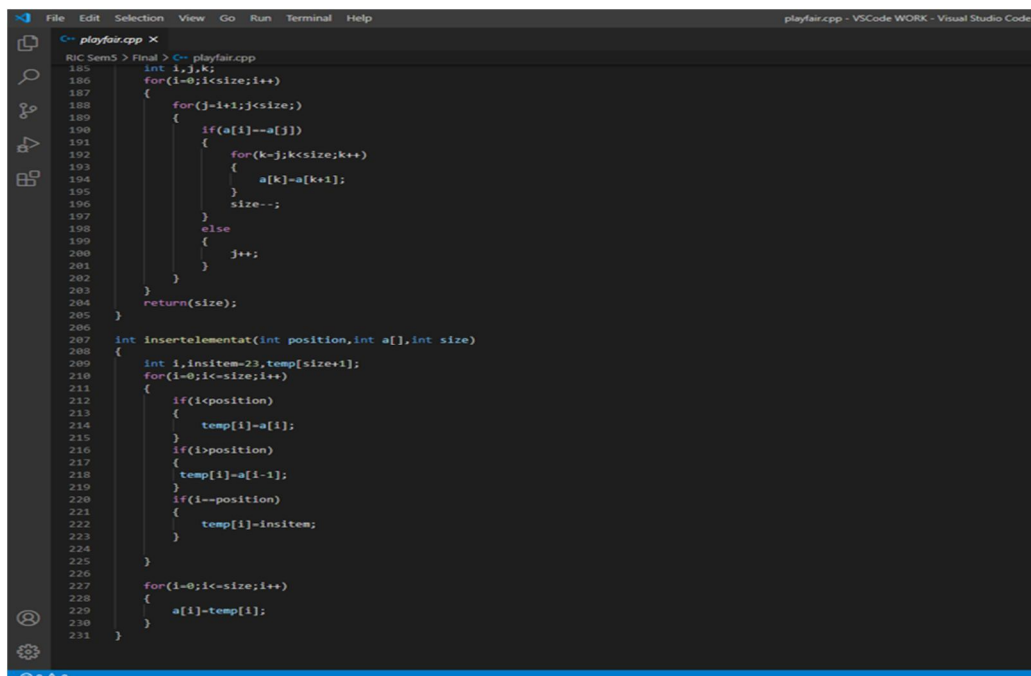
```

File Edit Selection View Go Run Terminal Help
playfair.cpp - VSCode WORK - Visual Studio Code

C++ playfair.cpp x
RIC Sem5 > Final > C++ playfair.cpp
143         col1=5+col1;
144     }
145     if(col2<0)
146     {
147         col2=5+col2;
148     }
149     numcipher[k]=cipherkey[row1][col1];
150     numcipher[k+1]=cipherkey[row2][col2];
151 }
152 if(col1==col2)
153 {
154     row1=(row1-1)%5;
155     row2=(row2-1)%5;
156     if(row1<0)
157     {
158         row1=5+row1;
159     }
160     if(row2<0)
161     {
162         row2=5+row2;
163     }
164     numcipher[k]=cipherkey[row1][col1];
165     numcipher[k+1]=cipherkey[row2][col2];
166 }
167 if(row1!=row2&&col1==col2)
168 {
169     numcipher[k]=cipherkey[row1][col2];
170     numcipher[k+1]=cipherkey[row2][col1];
171 }
172 }
173 printf("\nCipher Text of the entered string is - ");
174
175 for(i=0;i<lennumstr;i++)
176 {
177     if((numcipher[i]+'A')!=='X')//Should remove extra 'X' which were created during Encryption
178     printf("%c",numcipher[i]+'A');
179 }
180 printf("\n");
181 }
182
183 int removeRepeated(int size,int a[])
184 {
185     int i,j,k;
186     for(i=0;i<size;i++)
187     {
188         for(j=i+1;j<size;j++)
189         {
190             if(a[i]==a[j])
191             {

```

Figure 6(d)



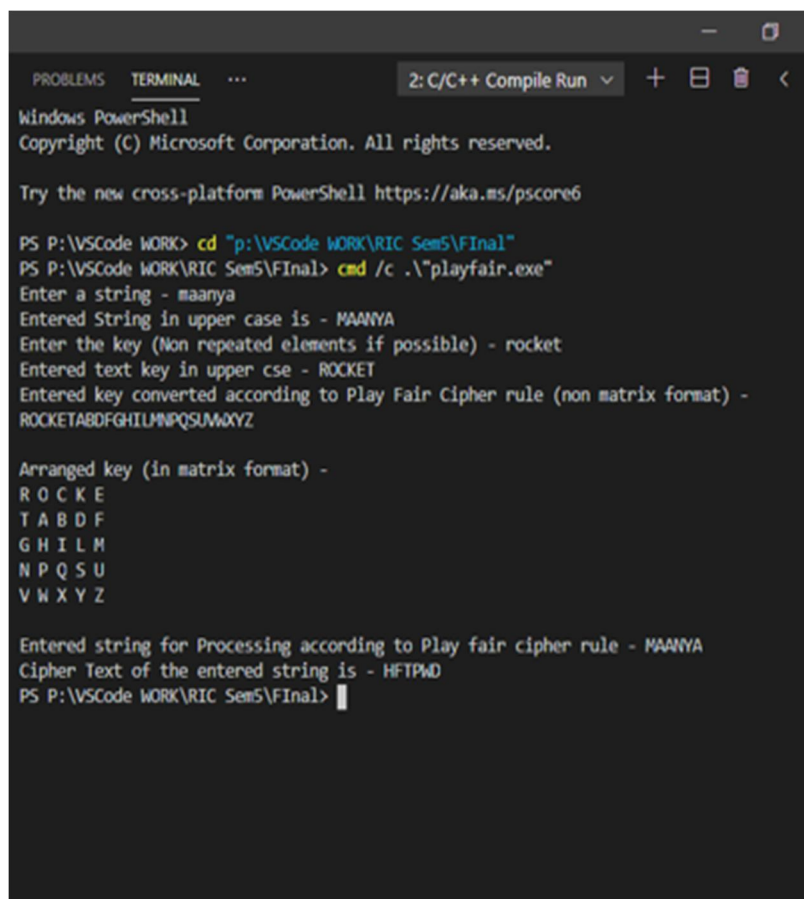
```

185 int i,j,k;
186 for(i=0;i<size;i++)
187 {
188     for(j=i+1;j<size;j++)
189     {
190         if(a[i]==a[j])
191         {
192             for(k=j;k<size;k++)
193             {
194                 a[k]=a[k+1];
195             }
196             size--;
197         }
198         else
199         {
200             j++;
201         }
202     }
203     return(size);
204 }
205
206 int insertelementat(int position,int a[],int size)
207 {
208     int i,insitem=23,temp[size+1];
209     for(i=0;i<size;i++)
210     {
211         if(i<position)
212         {
213             temp[i]=a[i];
214         }
215         if(i>position)
216         {
217             temp[i]=a[i-1];
218         }
219         if(i==position)
220         {
221             temp[i]=insitem;
222         }
223     }
224 }
225
226 for(i=0;i<size;i++)
227 {
228     a[i]=temp[i];
229 }
230 }
231

```

Figure 6 (e)

Figure 6(a), 6(b), 6(c), 6(d) and 6(e) - Source Code of PlayFair Cipher



```

PS P:\VSCode WORK> cd "p:\VSCode WORK\RIC Sem5\Final"
PS P:\VSCode WORK\RIC Sem5\Final> cmd /c .\playfair.exe
Enter a string - maanya
Entered String in upper case is - MAANYA
Enter the key (Non repeated elements if possible) - rocket
Entered text key in upper case - ROCKET
Entered key converted according to Play Fair Cipher rule (non matrix format) -
ROCKETABDFGHIJLMNPQSUWXYZ

Arranged key (in matrix format) -
R O C K E
T A B D F
G H I L M
N P Q S U
V W X Y Z

Entered string for Processing according to Play fair cipher rule - MAANYA
Cipher Text of the entered string is - HFTPMQ
PS P:\VSCode WORK\RIC Sem5\Final>

```

Figure 7. Output of PlayFair Cipher

A. Comparative Analysis Of RSA, Caesar Cipher, Playfair Cipher

Table 2. A comparative analysis of RSA, Caesar Cipher and Playfair Cipher

S.no	Name of algorithm	Features/Functionality	Complexity	Security/Drawbacks
1.	RSA	<ul style="list-style-type: none"> • RSA creates digital signatures. • RSA is also used to verify the digital signatures. • RSA performs encryption and decryption in the memory strings or in the byte arrays of any size. It is not size specific. • Performing RSA, gives a method to ensure confidentiality, integrity, authenticity and also the non-repudiation of communications held electronically and also to the data stored. 	<ul style="list-style-type: none"> • The calculated time complexity of the RSA algorithm is $O(n^2)$. It is also observed that as the size of private key length increases, the increase in time becomes exponential and nonlinear. • The relation between the private key length and the run time memory is approximated as a polynomial equation of order 2 and thus, the space complexity of RSA can be expressed as $O(n^2)$. 	<ul style="list-style-type: none"> • RSA works mainly by using the product of two prime numbers as a trapdoor function. Thus, to break an RSA cipher, it requires factoring very large numbers. • The RSA algorithm can be quite slow in cases where a large amount of data needs to be encrypted by the same device. • It also needs a third party to verify the reliability of public keys.
2..	Caesar Cipher	<ul style="list-style-type: none"> • The Caesar Cipher is a type of substitution cipher that encrypts the data by replacing the original letters with those "x" number of characters ahead in the alphabet. • The Caesar cipher is not that secure and it can be easily broken even in a ciphertext-only scenario. There are two possible: 1) an attacker knows or guesses that some sort of simple substitution cipher has been used, though he might not be aware that specifically it is a Caesar scheme; and 2) an attacker knows that a Caesar cipher is used to encrypt the data, but does not know the exact shift value. • With 26 letters in the English alphabet, the possible permutations are $26!$ (Factorial of 26) which equals 4×10^{26}. The sender and the receiver may choose any one of the possible permutations as a ciphertext alphabet. 	<ul style="list-style-type: none"> • In Caesar cipher encryption/decryption is done by calculating the result of applying all of the $n-1$ (i.e., 25), the computational complexity is just $O(n)$. 	<ul style="list-style-type: none"> • Caesar Cipher is not a very secure cryptosystem as there are only 26 possible keys to try out and an attacker can carry out an exhaustive key search with available computing resources. • The frequency of the letter pattern often provides a big hint in decoding the complete message.

3.	Playfair Cipher	<ul style="list-style-type: none"> In plaintext digraphs encryption is done with the matrix by first locating the two plaintext letters in the matrix. They are either in different rows/ columns or in the same row/ column. The encryption is done using a 5×5-square matrix containing the letters of the alphabet and the letters I and J are treated as the same. Decrypting the Playfair cipher is also quite simple as it involves doing the same process in reverse. The receiver has the same key and can thus create the same key table, and then decrypt any messages made using that particular key. 	<ul style="list-style-type: none"> A Playfair cipher is comparatively harder to cryptanalyze than a monoalphabetic cipher. This is because it is done on pairs of letters instead of individual letters and this Frequency Analysis is significantly difficult to crack. In the case of the Playfair Cipher, one cannot encrypt to a double letter, so we have to remove the 26 possibilities of double letters, which gives us 650 possible digraphs that we will have to check. 	<ul style="list-style-type: none"> Ciphering methods should satisfy the properties of confusion and diffusion for them to be successful whereas the playfair cipher only provides the property of confusion. <p>diffusion – This property is related with the driving away of statistical structure of plaintext over the bulk of ciphertext</p> <p>confusion – This property makes the relationship between the ciphertext and the key as complex as possible.</p> <ul style="list-style-type: none"> The Playfair cipher was used to protect important, yet non-critical secrets, because it was quick and easy to use and it required no special equipment/tool.
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X. CONCLUSION

Cryptography is one of the most important things in our lives today. All the data exchanged is expected to be safe from any intervention in between the sender and the receiver, hence cryptography plays a big role in today's world. Encryption and Decryption are the two main processes to perform cryptography. Everyone wishes their data to be encrypted from their end and to only be decrypted at the authentic user's end, and nowhere in between.

A lot of strategies/techniques/algorithms are used to perform cryptography. Three amongst them namely, RSA, Caesar Cipher and Playfair Cipher were implemented to have a comparative analysis to check their features/functionality, complexity, the level of security they provide and also the drawbacks faced with them. All these three were performed on an open source platform, Visual Studio Code version 1.49.3.

Implementing and Comparing these three techniques for cryptography, we conclude that Asymmetric Encryption (also known as Public Key Encryption) is more secure than Symmetric Encryption (also known as Private Key Encryption). Though it's more complex than the symmetric encryption technique, the approach of using two different keys, one for encryption and the other for decryption makes it more difficult for an attacker to break the encryption and get the original data out of it. Asymmetric cryptography is performed with large prime numbers giving more security to the data encrypted.

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