Cryptography and Network Security

Practical List

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Practical 1

Aim – Overview of Cryptography and Network Security

Theory –

Cryptography

Cryptography is the practice and study of techniques for secure communication in the presence of third parties called adversaries. It involves developing and analyzing protocols that prevent malicious third parties from retrieving information being shared between two entities.

Principles of Cryptography

The primary goals of cryptography are:

- **Confidentiality:** Ensuring that only authorized parties can access and understand data.
- **Integrity:** Protecting data from unauthorized modification or corruption.
- **Availability:** Guaranteeing that data and systems are accessible when needed.
- **Authentication:** Verifying the identity of communicating parties.
- **Non-repudiation:** Preventing parties from denying previous actions or commitments.

Diagram and Explanation

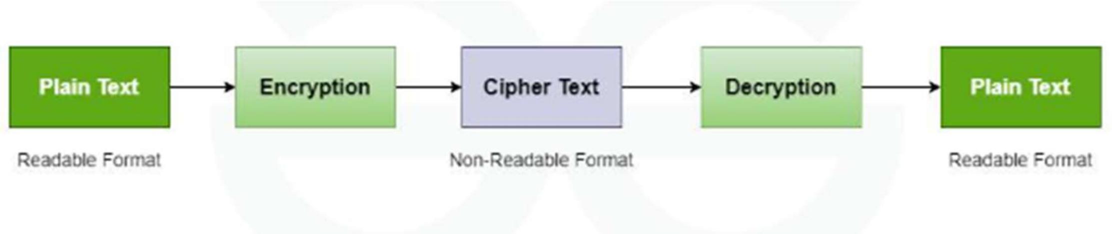


Fig: Basic Cryptography Process

The diagram illustrates the fundamental process of cryptography:

- **Plaintext:** The original, readable data.
- **Encryption:** The process of converting plaintext into ciphertext using an encryption algorithm and a key.
- **Ciphertext:** The encrypted, unreadable data.
- **Decryption:** The process of converting ciphertext back into plaintext using the decryption algorithm and the key.

Importance of Cryptography

Cryptography is essential for protecting sensitive information in today's digital world. Its applications include:

- **Secure communication:** Protecting data transmitted over networks.
- **Data protection:** Safeguarding data at rest (e.g., in databases).
- **Digital signatures:** Verifying the authenticity and integrity of digital documents.
- **Authentication:** Verifying the identity of users and systems.

Cryptography Attacks

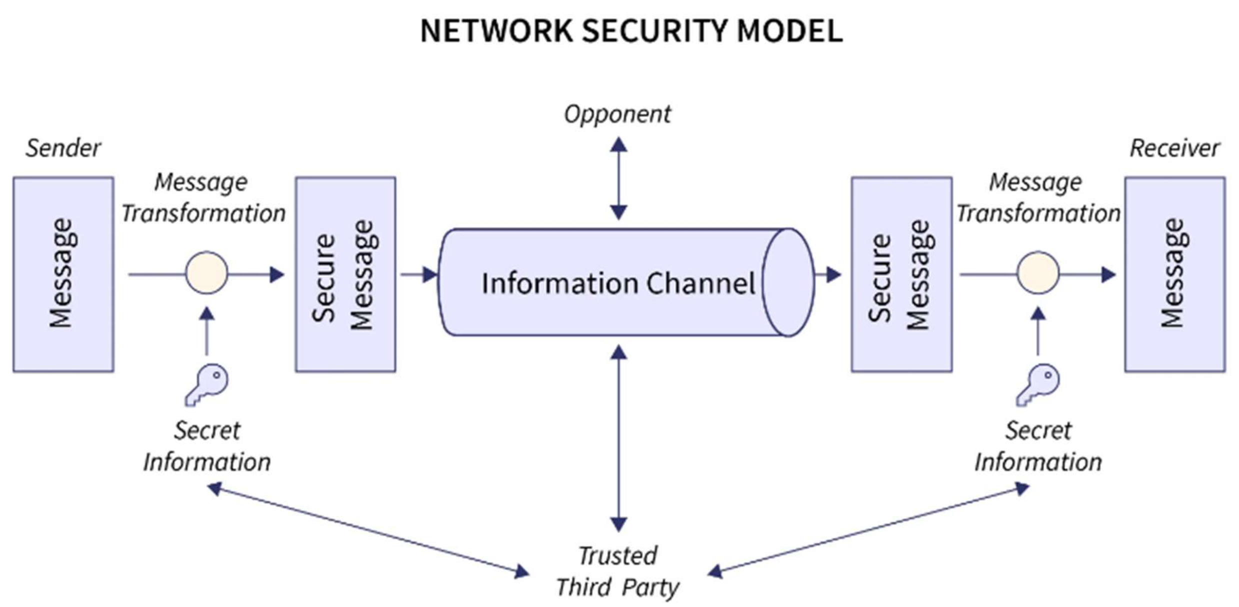
Cryptography attacks aim to compromise the security of cryptographic systems. Common types include:

- **Ciphertext-only attack:** The attacker has access only to the ciphertext.
- **Known-plaintext attack:** The attacker has access to both plaintext and corresponding ciphertext.
- **Chosen-plaintext attack:** The attacker can choose plaintexts and obtain the corresponding ciphertexts.
- **Man-in-the-middle attack:** An attacker intercepts and modifies communication between two parties.

Network Security

Network security involves protecting a computer network and its data from unauthorized access, use, disclosure, disruption, modification, or destruction. It encompasses hardware, software, and procedural measures.

Network Security Model



The network security model represents the secure communication between sender and receiver. This model depicts how the security service has been implemented over the network to prevent the opponent from causing a threat to the authenticity or confidentiality of the data that is being communicated through the network.

- Network security covers a huge amount of technologies, devices, and processes
- In simple words, it is a set of rules and regulations designed for protecting and securing the integrity, confidentiality, and accessibility of data and computer networks.
- The most common example of network security is password protection which was chosen by itself.

Security Attacks

Network security attacks can be classified into:

- **Passive attacks:** A Passive attack attempts to learn or make use of information from the system but does not affect system resources.
    - **Eavesdropping:** Unauthorized interception of network traffic to capture sensitive data.
    - **Traffic analysis:** Analyzing network traffic patterns to infer information.
- **Active attacks:** Active attacks are a type of cybersecurity attack in which an attacker attempts to alter, destroy, or disrupt the normal operation of a system or network.
    - **Masquerade:** Impersonating a legitimate entity to gain unauthorized access.
    - **Replay attack:** Reusing previously captured data to gain unauthorized access.
    - **Denial of Service (DoS) attack:** Overwhelming a system or network with excessive traffic to render it unavailable.

Importance of Network Security

Network security is crucial for protecting sensitive data, maintaining business operations, and safeguarding against cyber threats. It helps build trust with customers and partners.

Applications of Network Security

Network security is applied in various domains:

- **E-commerce:** Protecting online transactions.
- **Online banking:** Securing financial information.
- **Healthcare:** Protecting patient data.
- **Government:** Safeguarding national security information.

Conclusion –

Cryptography and network security are fundamental to protecting digital assets and ensuring secure communication. They are essential components of modern information systems and require ongoing attention to address evolving threats.

Practical 2

Aim – To write a program to implement Playfair cipher for encryption and decryption.

Theory –

The Playfair cipher is a polygraphic substitution cipher that encrypts pairs of letters (digraphs) instead of single letters.

It was invented by Charles Wheatstone in 1854 and was used by the British military during the Boer War.

1. **Key Generation:**
    - Create a 5x5 square grid (matrix) filled with the letters of the alphabet, excluding the letter 'J' (which is considered equivalent to 'I').
    - Fill the remaining empty spaces with the remaining letters of the alphabet, starting with the letter 'I'.
    - The key is the 5x5 square grid.
2. **Encryption:**
    - Break the plaintext into pairs of letters. If there is an odd number of letters, add a 'X' to the end.
    - For each pair of letters:
        - If the two letters are in the same row of the key, replace each letter with the letter to its right (wrapping around if necessary).
        - If the two letters are in the same column of the key, replace each letter with the letter below it (wrapping around if necessary).
        - If the two letters are not in the same row or column, find the rectangle formed by the two letters. Replace each letter with the letter diagonally opposite it in the rectangle.
3. **Decryption:**
    - The decryption process is the reverse of the encryption process.
    - For each pair of ciphertext letters:
        - If the two letters are in the same row of the key, replace each letter with the letter to its left (wrapping around if necessary).
        - If the two letters are in the same column of the key, replace each letter with the letter above it (wrapping around if necessary).
        - If the two letters are not in the same row or column, find the rectangle formed by the two letters. Replace each letter with the letter diagonally opposite it in the rectangle.
        - Remove any 'X' letters added during encryption.

Program –

```
# Function to generate the Playfair cipher key matrix
def generate_key_matrix(key):
    key = key.upper().replace("J", "I")  # Replace 'J' with 'I' as Playfair usually uses a 5x5 matrix
    key_matrix = []
    seen = set()

    # Add key characters to the matrix
    for char in key:
        if char not in seen and char.isalpha():
            seen.add(char)
            key_matrix.append(char)

    # Add remaining letters of the alphabet to the matrix
    for char in "ABCDEFGHIKLMNOPQRSTUVWXYZ":  # 'J' is omitted
        if char not in seen:
            seen.add(char)
            key_matrix.append(char)

    # Convert the list into a 5x5 matrix
    return [key_matrix[i:i+5] for i in range(0, 25, 5)]

# Function to find the position of a letter in the key matrix
def find_position(matrix, char):
    for i, row in enumerate(matrix):
        if char in row:
            return i, row.index(char)
    return None

# Function to preprocess the plaintext (handle repeating characters and add filler)
def preprocess_text(plaintext):
    plaintext = plaintext.upper().replace("J", "I")  # Replace 'J' with 'I'
    processed = ""

    i = 0
    while i < len(plaintext):
        char1 = plaintext[i]
        if i + 1 < len(plaintext):
            char2 = plaintext[i + 1]
        else:
            char2 = 'X'  # Add filler if it's the last letter

        if char1 == char2:
            processed += char1 + 'X'  # Insert 'X' between repeated letters
            i += 1
        else:
            processed += char1 + char2
            i += 2

    if len(processed) % 2 != 0:
```

```
        processed += 'X'  # Add filler if the text length is odd

    return processed

# Function to encrypt/decrypt a digraph (pair of letters)
def process_digraph(matrix, char1, char2, encrypt=True):
    row1, col1 = find_position(matrix, char1)
    row2, col2 = find_position(matrix, char2)

    if row1 == row2:  # Same row
        if encrypt:
            return matrix[row1][(col1 + 1) % 5] + matrix[row2][(col2 + 1) % 5]
        else:
            return matrix[row1][(col1 - 1) % 5] + matrix[row2][(col2 - 1) % 5]
    elif col1 == col2:  # Same column
        if encrypt:
            return matrix[(row1 + 1) % 5][col1] + matrix[(row2 + 1) % 5][col2]
        else:
            return matrix[(row1 - 1) % 5][col1] + matrix[(row2 - 1) % 5][col2]
    else:  # Rectangle case
        return matrix[row1][col2] + matrix[row2][col1]

# Function to encrypt plaintext using Playfair cipher
def encrypt(plaintext, key):
    key_matrix = generate_key_matrix(key)
    plaintext = preprocess_text(plaintext)
    ciphertext = ""

    for i in range(0, len(plaintext), 2):
        ciphertext += process_digraph(key_matrix, plaintext[i], plaintext[i + 1], encrypt=True)

    return ciphertext

# Function to decrypt ciphertext using Playfair cipher
def decrypt(ciphertext, key):
    key_matrix = generate_key_matrix(key)
    plaintext = ""

    for i in range(0, len(ciphertext), 2):
        plaintext += process_digraph(key_matrix, ciphertext[i], ciphertext[i + 1], encrypt=False)

    return plaintext

# Main program
def main():
    print("Playfair Cipher")
    key = input("Enter the key: ")
    choice = input("Encrypt or Decrypt (e/d): ").lower()

    if choice == 'e':
        plaintext = input("Enter the plaintext: ")
        ciphertext = encrypt(plaintext, key)
```

```
        print(f"Ciphertext: {ciphertext}")
    elif choice == 'd':
        ciphertext = input("Enter the ciphertext: ")
        plaintext = decrypt(ciphertext, key)
        print(f"Plaintext: {plaintext}")
    else:
        print("Invalid choice. Please enter 'e' to encrypt or 'd' to decrypt.")

if __name__ == "__main__":
    main()
```

<u>Output</u> –

```
Playfair Cipher
Enter the key: PLAYFAIR
Encrypt or Decrypt (e/d): e
Enter the plaintext: PRATIK
Ciphertext: LIFQCE
```

```
Playfair Cipher
Enter the key: PLAYFAIR
Encrypt or Decrypt (e/d): d
Enter the ciphertext: LIFQCE
Plaintext: PRATIK
```

<u>Conclusion</u> –

Hence, we have performed the Playfair cipher implementation for encryption and decryption successfully.

Practical 3

Aim – To write a program to implement Hill cipher for encryption and decryption.

Theory –

The Hill Cipher uses a polygraphic substitution cipher, which means homogeneous substitution over many levels of blocks.

This polygraphic substitution cipher allows Hill Cipher to function easily with digraphs (two-letter blocks), trigraphs (three-letter blocks), or any other multiple-sized blocks to create a uniform cipher.

Hill Cipher is based on linear algebra, advanced matrices (matrix multiplication and matrix inverses), and modulo arithmetic principles. Obviously, it is a more mathematical cipher than others.

Hill Cipher is also a block cipher. A block cipher uses a deterministic algorithm and a symmetric key to encrypt a block of text.

Unlike stream ciphers, it does not require encrypting one bit at a time. Hill Cipher is a block cipher, which means it can function with any block size.

While Hill Cipher is digraphic in nature, it can grow to multiply any letter size, adding complexity and reliability for improved usage.

Because most of Hill Ciphers' problems and solutions are mathematical in nature, it is simple to hide letters with precision.

Encryption Process:

1. **Convert to Numerical Values:** Convert each plaintext letter to a numerical value (e.g., A=0, B=1, ..., Z=25).
2. **Form Plaintext Vectors:** Divide the plaintext into groups of letters and represent each group as a column vector.
3. **Matrix Multiplication:** Multiply each plaintext vector by the key matrix. The result is the corresponding ciphertext vector.
4. **Convert to Ciphertext:** Convert the numerical values in the ciphertext vector back to letters.
5. Encrypting using the Hill cipher depends on the following operations –

   $$E(K, P) = (K*P) \bmod 26$$

   Here K is our key matrix, and P is the vectorized plaintext.

Decryption Process:

1. **Convert to Numerical Values:** Convert each ciphertext letter to a numerical value.
2. **Form Ciphertext Vectors:** Divide the ciphertext into groups of letters and represent each group as a column vector.
3. **Inverse Matrix Multiplication:** Multiply each ciphertext vector by the inverse of the key matrix. The result is the corresponding plaintext vector.

4. **Convert to Plaintext:** Convert the numerical values in the plaintext vector back to letters.
5. The Hill cipher decryption process is based on the following operation –

   D(K, C) = (K-1 *C) mod 26

   Here C is the vectorized ciphertext and K is our key matrix.

Program –

```
import math

def get_key_matrix_from_word(word, n):
  word = word.upper().replace(" ", "")
  key_numbers = [ord(char) - ord('A') for char in word if char.isalpha()]

  if len(key_numbers) < n * n:
    print(f"Key too short, padding with 'A'.")
    key_numbers += [0] * (n * n - len(key_numbers))  # Pad with 'A' (i.e., 0)
  elif len(key_numbers) > n * n:
    print(f"Key too long, truncating.")
    key_numbers = key_numbers[:n * n]  # Truncate extra characters

  key_matrix = []
  for i in range(n):
    key_matrix.append(key_numbers[i * n: (i + 1) * n])

  return key_matrix

def text_to_numbers(text):
  text = text.upper()
  numbers = [ord(char)-ord('A') for char in text if char.isalpha()]
  return numbers

def numbers_to_text(numbers):
  text = ''.join([chr(num%26 + ord('A')) for num in numbers])
  return text

def matrix_multiply_modulo(matrix, vector, modulus):
  n = len(matrix)
  result = []
  for i in range(n):
    s = 0
    for j in range(n):
      s += matrix[i][j] * vector[j]
    result.append(s % modulus)
  return result

def matrix_determinant(matrix):
  n = len(matrix)
  if n == 2:
    a, b = matrix[0]
```

```
        c, d = matrix[1]
        det = a*d - b*c
    elif n == 3:
        a, b, c = matrix[0]
        d, e, f = matrix[1]
        g, h, i = matrix[2]
        det = (a*e*i + b*f*g + c*d*h) - (c*e*g + b*d*i + a*f*h)
    else:
        print("Determinant not implemented for matrices larger than 3x3.")
        return None
    return det % 26

def modular_inverse(a, modulus):
    a = a % modulus
    for x in range(1, modulus):
        if (a * x) % modulus == 1:
            return x
    return None

def matrix_inverse_modulo(matrix, modulus):
    n = len(matrix)
    det = matrix_determinant(matrix)
    det_inv = modular_inverse(det, modulus)
    if det_inv is None:
        print(f"Determinant {det} has no inverse modulo {modulus}.")
        return None
    if n == 2:
        a, b = matrix[0]
        c, d = matrix[1]
        # Compute adjugate matrix
        adjugate = [[d, -b], [-c, a]]
        # Bring adjugate elements into the range [0, modulus)
        for i in range(n):
            for j in range(n):
                adjugate[i][j] = adjugate[i][j] % modulus
        # Multiply adjugate by determinant inverse modulo modulus
        inverse = []
        for row in adjugate:
            inverse_row = [(det_inv * element) % modulus for element in row]
            inverse.append(inverse_row)
        return inverse
    else:
        print("Matrix inverse not implemented for matrices larger than 2x2.")
        return None

def prepare_text(text, block_size):
    numbers = text_to_numbers(text)
    if len(numbers) % block_size != 0:
        padding_length = block_size - (len(numbers) % block_size)
        numbers += [text_to_numbers('X')[0]] * padding_length
    return numbers
```

```python
def encrypt(plaintext_numbers, key_matrix, modulus):
    n = len(key_matrix)
    ciphertext_numbers = []
    for i in range(0, len(plaintext_numbers), n):
        block = plaintext_numbers[i:i+n]
        cipher_block = matrix_multiply_modulo(key_matrix, block, modulus)
        ciphertext_numbers.extend(cipher_block)
    return ciphertext_numbers

def decrypt(ciphertext_numbers, inverse_key_matrix, modulus):
    n = len(inverse_key_matrix)
    plaintext_numbers = []
    for i in range(0, len(ciphertext_numbers), n):
        block = ciphertext_numbers[i:i+n]
        plain_block = matrix_multiply_modulo(inverse_key_matrix, block, modulus)
        plaintext_numbers.extend(plain_block)
    return plaintext_numbers

def main():
    modulus = 26
    print("Hill Cipher Encryption and Decryption")
    word_key = input("Enter the word key: ")
    n = 2  # Only support 2x2 matrices for now
    key_matrix = get_key_matrix_from_word(word_key, n)

    print("Key Matrix:")
    for row in key_matrix:
        print(row)

    det = matrix_determinant(key_matrix)
    det_inv = modular_inverse(det, modulus)
    if det_inv is None:
        print(f"The determinant ({det}) is not invertible modulo {modulus}. Cannot proceed.")
        return

    plaintext = input("Enter the plaintext: ")
    plaintext_numbers = prepare_text(plaintext, n)
    ciphertext_numbers = encrypt(plaintext_numbers, key_matrix, modulus)
    ciphertext = numbers_to_text(ciphertext_numbers)
    print("Ciphertext:", ciphertext)

    # Now, decrypt
    inverse_key_matrix = matrix_inverse_modulo(key_matrix, modulus)
    if inverse_key_matrix is None:
        print("Cannot compute inverse key matrix. Decryption not possible.")
        return
    decrypted_numbers = decrypt(ciphertext_numbers, inverse_key_matrix, modulus)
    decrypted_text = numbers_to_text(decrypted_numbers)
    print("Decrypted text:", decrypted_text)

if __name__ == "__main__":
    main()
```

<u>Output</u> –

```
Hill Cipher Encryption and Decryption
Enter the word key: HEAT
Key Matrix:
[7, 4]
[0, 19]
Enter the plaintext: PLAY
Ciphertext: TBSO
Decrypted text: PLAY
```

<u>Conclusion</u> –

Hence, we have performed the Hill cipher implementation for encryption and decryption successfully.

Practical 4

Aim – To write a program to implement DES algorithm.

Theory –

The Data Encryption Standard algorithm is a block cipher algorithm that takes in 64-bit blocks of plaintext at a time as input and produces 64-bit blocks of cipher text at a time, using a 48-bit key for each input.

In block cipher algorithms, the text to be encrypted is broken into ‘blocks’ of text, and each block is encrypted separately using the key.

The decryption process is the exact opposite of the encryption. It takes in a 64 bit block of ciphertext, and produces the 64 bit block of plaintext using the same 48 bit key during encryption.

The encryptor and the decryptor need to use the same key, otherwise, they will not be able to communicate together.

The DES algorithm was successful in the early days of the internet, but its short key length of 56 bits makes it too insecure for today’s applications.

With the evolution of technology and the increase in computing power, an attacker with sufficient computing resources can break the key within a few minutes.

It has however been highly influential in the development and advancement of cryptography.

Program –

```
#initail permutation
ip_table = [
   58, 50, 42, 34, 26, 18, 10, 2,
   60, 52, 44, 36, 28, 20, 12, 4,
   62, 54, 46, 38, 30, 22, 14, 6,
   64, 56, 48, 40, 32, 24, 16, 8,
   57, 49, 41, 33, 25, 17, 9, 1,
   59, 51, 43, 35, 27, 19, 11, 3,
   61, 53, 45, 37, 29, 21, 13, 5,
   63, 55, 47, 39, 31, 23, 15, 7
]
# PC1 permutation table
pc1_table = [
   57, 49, 41, 33, 25, 17, 9, 1,
   58, 50, 42, 34, 26, 18, 10, 2,
   59, 51, 43, 35, 27, 19, 11, 3,
   60, 52, 44, 36, 63, 55, 47, 39,
   31, 23, 15, 7, 62, 54, 46, 38,
   30, 22, 14, 6, 61, 53, 45, 37,
   29, 21, 13, 5, 28, 20, 12, 4
]
# Define the left shift schedule for each round
```

```
shift_schedule = [1, 1, 2, 2,
                  2, 2, 2, 2,
                  1, 2, 2, 2,
                  2, 2, 2, 1]

# PC2 permutation table
pc2_table = [
    14, 17, 11, 24, 1, 5, 3, 28,
    15, 6, 21, 10, 23, 19, 12, 4,
    26, 8, 16, 7, 27, 20, 13, 2,
    41, 52, 31, 37, 47, 55, 30, 40,
    51, 45, 33, 48, 44, 49, 39, 56,
    34, 53, 46, 42, 50, 36, 29, 32
]
#expension
e_box_table = [
    32, 1, 2, 3, 4, 5,
    4, 5, 6, 7, 8, 9,
    8, 9, 10, 11, 12, 13,
    12, 13, 14, 15, 16, 17,
    16, 17, 18, 19, 20, 21,
    20, 21, 22, 23, 24, 25,
    24, 25, 26, 27, 28, 29,
    28, 29, 30, 31, 32, 1
]

# S-box tables for DES
s_boxes = [
    # S-box 1
    [
        [14, 4, 13, 1, 2, 15, 11, 8, 3, 10, 6, 12, 5, 9, 0, 7],
        [0, 15, 7, 4, 14, 2, 13, 1, 10, 6, 12, 11, 9, 5, 3, 8],
        [4, 1, 14, 8, 13, 6, 2, 11, 15, 12, 9, 7, 3, 10, 5, 0],
        [15, 12, 8, 2, 4, 9, 1, 7, 5, 11, 3, 14, 10, 0, 6, 13]
    ],
    # S-box 2
    [
        [15, 1, 8, 14, 6, 11, 3, 4, 9, 7, 2, 13, 12, 0, 5, 10],
        [3, 13, 4, 7, 15, 2, 8, 14, 12, 0, 1, 10, 6, 9, 11, 5],
        [0, 14, 7, 11, 10, 4, 13, 1, 5, 8, 12, 6, 9, 3, 2, 15],
        [13, 8, 10, 1, 3, 15, 4, 2, 11, 6, 7, 12, 0, 5, 14, 9]
    ],
    # S-box 3
    [
        [10, 0, 9, 14, 6, 3, 15, 5, 1, 13, 12, 7, 11, 4, 2, 8],
        [13, 7, 0, 9, 3, 4, 6, 10, 2, 8, 5, 14, 12, 11, 15, 1],
        [13, 6, 4, 9, 8, 15, 3, 0, 11, 1, 2, 12, 5, 10, 14, 7],
        [1, 10, 13, 0, 6, 9, 8, 7, 4, 15, 14, 3, 11, 5, 2, 12]
    ],
    # S-box 4
    [
        [7, 13, 14, 3, 0, 6, 9, 10, 1, 2, 8, 5, 11, 12, 4, 15],
```

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

def str_to_bin(user_input):
    binary_representation = ''.join(format(ord(char), '08b') for char in user_input)
```

```
    binary_representation = binary_representation[:64].ljust(64, '0')  # Ensure it's 64 bits long
    return binary_representation

def binary_to_ascii(binary_str):
    ascii_str = ''.join([chr(int(binary_str[i:i+8], 2)) for i in range(0, len(binary_str), 8)])
    return ascii_str.rstrip()  # Remove any padding

def binary_to_hex(binary_str):
    return hex(int(binary_str, 2))[2:].upper().zfill(16)  # Convert binary to hex

def hex_to_binary(hex_str):
    return bin(int(hex_str, 16))[2:].zfill(64)  # Convert hex to binary

def ip_on_binary_rep(binary_representation):
    ip_result = ''.join(binary_representation[ip_table[i] - 1] for i in range(64))
    return ip_result

def key_in_binary_conv(hex_key):
    binary_representation_key = ''.join(format(int(hex_key[i:i+2], 16), '08b') for i in range(0, len(hex_key), 2))
    return binary_representation_key

def generate_round_keys(hex_key):
    binary_representation_key = key_in_binary_conv(hex_key)
    pc1_key_str = ''.join(binary_representation_key[bit - 1] for bit in pc1_table)

    c0, d0 = pc1_key_str[:28], pc1_key_str[28:]
    round_keys = []

    for round_num in range(16):
        c0 = c0[shift_schedule[round_num]:] + c0[:shift_schedule[round_num]]
        d0 = d0[shift_schedule[round_num]:] + d0[:shift_schedule[round_num]]
        cd_concatenated = c0 + d0
        round_key = ''.join(cd_concatenated[bit - 1] for bit in pc2_table)
        round_keys.append(round_key)

    return round_keys

def encryption(user_input, hex_key):
    binary_rep_of_input = str_to_bin(user_input)
    round_keys = generate_round_keys(hex_key)
    ip_result_str = ip_on_binary_rep(binary_rep_of_input)
    lpt, rpt = ip_result_str[:32], ip_result_str[32:]

    for round_num in range(16):
        expanded_result_str = ''.join(rpt[e_box_table[i] - 1] for i in range(48))
        round_key_str = round_keys[round_num]
        xor_result_str = ''.join(str(int(expanded_result_str[i]) ^ int(round_key_str[i])) for i in range(48))
        six_bit_groups = [xor_result_str[i:i + 6] for i in range(0, 48, 6)]
        s_box_substituted = ''

        for i in range(8):
            row_bits = int(six_bit_groups[i][0] + six_bit_groups[i][-1], 2)
```

```
            col_bits = int(six_bit_groups[i][1:-1], 2)
            s_box_value = s_boxes[i][row_bits][col_bits]
            s_box_substituted += format(s_box_value, '04b')

        p_box_result = ''.join(s_box_substituted[p_box_table[i] - 1] for i in range(32))
        new_rpt_str = ''.join(str(int(lpt[i]) ^ int(p_box_result[i])) for i in range(32))
        lpt, rpt = rpt, new_rpt_str

    final_result = rpt + lpt
    final_cipher = ''.join(final_result[ip_inverse_table[i] - 1] for i in range(64))
    final_cipher_hex = binary_to_hex(final_cipher)
    print("Final Ciphertext (Hex):", final_cipher_hex)

    return final_cipher_hex

def decryption(final_cipher_hex, hex_key):
    round_keys = generate_round_keys(hex_key)
    final_cipher_bin = hex_to_binary(final_cipher_hex)
    ip_dec_result_str = ip_on_binary_rep(final_cipher_bin)
    lpt, rpt = ip_dec_result_str[:32], ip_dec_result_str[32:]

    for round_num in range(16):
        expanded_result_str = ''.join(rpt[e_box_table[i] - 1] for i in range(48))
        round_key_str = round_keys[15 - round_num]
        xor_result_str = ''.join(str(int(expanded_result_str[i]) ^ int(round_key_str[i])) for i in range(48))
        six_bit_groups = [xor_result_str[i:i + 6] for i in range(0, 48, 6)]
        s_box_substituted = ''

        for i in range(8):
            row_bits = int(six_bit_groups[i][0] + six_bit_groups[i][-1], 2)
            col_bits = int(six_bit_groups[i][1:-1], 2)
            s_box_value = s_boxes[i][row_bits][col_bits]
            s_box_substituted += format(s_box_value, '04b')

        p_box_result = ''.join(s_box_substituted[p_box_table[i] - 1] for i in range(32))
        new_rpt_str = ''.join(str(int(lpt[i]) ^ int(p_box_result[i])) for i in range(32))
        lpt, rpt = rpt, new_rpt_str

    final_result = rpt + lpt
    final_plain_bin = ''.join(final_result[ip_inverse_table[i] - 1] for i in range(64))
    final_plain_str = binary_to_ascii(final_plain_bin)
    print("Decrypted Text:", final_plain_str)

    return final_plain_str

# User Interaction
operation = input("Do you want to (E)ncrypt or (D)ecrypt? ").strip().upper()
if operation == 'E':
    plaintext = input("Enter the plaintext (max 8 characters): ").strip()
    hex_key = input("Enter the key (in Hex, 16 characters): ").strip()
    cipher = encryption(plaintext, hex_key)
elif operation == 'D':
```

```
    ciphertext = input("Enter the ciphertext (in Hex): ").strip()
    hex_key = input("Enter the key (in Hex, 16 characters): ").strip()
    decrypted_text = decryption(ciphertext, hex_key)
else:
    print("Invalid operation selected.")
```

<u>Output</u> –

```
Do you want to (E)ncrypt or (D)ecrypt? E
Enter the plaintext (max 8 characters): Hello
Enter the key (in Hex, 16 characters): 1234abcd1234abcd
Final Ciphertext (Hex): 23313BE04F7D6F79
```

```
Do you want to (E)ncrypt or (D)ecrypt? D
Enter the ciphertext (in Hex): 23313BE04F7D6F79
Enter the key (in Hex, 16 characters): 1234abcd1234abcd
Decrypted Text: Hello
```

<u>Conclusion</u> –

Hence, we have successfully implemented DES algorithm.

Practical 5

Aim – To write a program to implement Blowfish Algorithm.

Theory –

Blowfish is a symmetric block cipher designed by Bruce Schneier in 1993.

It was intended as a replacement for DES (Data Encryption Standard) and IDEA (International Data Encryption Algorithm).

Blowfish is known for its speed, simplicity, and security, making it a popular choice for various cryptographic applications.

Key Points:

- **Block Size:** Blowfish operates on 64-bit blocks of data.
- **Key Length:** The key can be of any length between 32 and 448 bits.
- **Structure:** It uses a combination of Feistel network and substitution-permutation network (SPN) structures.
- **Key Expansion:** The key expansion process generates 18 subkeys of 32 bits each.

Blowfish Algorithm:

1. **Key Expansion:**
    - The key is divided into 16 32-bit subkeys.
    - An initialization vector (IV) is used to initialize the subkeys.
    - A series of iterations is performed to generate the remaining subkeys.
2. **Encryption:**
    - The plaintext is divided into 64-bit blocks.
    - Each block is processed in 16 rounds.
    - In each round:
        - The block is divided into two 32-bit halves, L and R.
        - The left half (L) is XORed with a subkey.
        - The result is passed through a substitution function (S-box) and XORed with the right half (R).
        - The right half (R) becomes the new left half (L) for the next round.
    - After 16 rounds, the halves are swapped, and the final ciphertext is obtained.

3. **Decryption:**
    - The ciphertext is divided into 64-bit blocks.
    - The same key expansion process is used.
    - The decryption process involves reversing the encryption steps, using the same subkeys in reverse order.

Program –

```
class Blowfish:
  def __init__(self, key):
    self.P = [0x243F6A88, 0x85A308D3, 0x13198A2E, 0x03707344,
         0xA4093822, 0x299F31D0, 0x082EFA98, 0xEC4E6C89,
         0x452821E6, 0x38D01377, 0xBE5466CF, 0x34E90C6C,
         0xC0AC29B7, 0xC97C50DD, 0x3F84D5B5, 0xB5470917,
         0x9216D5D9, 0x8979FB1B]
    self.S = [0xD1310BA6, 0x98DFB5AC, 0x2FFD72DB, 0xD01ADFB7,
         0xB8E1AFED, 0x6A267E96, 0xBA7C9045, 0xF12C7F99,
         0x24A19947, 0xB3916CF7, 0x0801F2E2, 0x858EFC16,
         0x636920D8, 0x71574E69, 0xA458FEA3, 0xF4933D7E]

  def F(self, x):
    return ((self.S[0] + x) * self.S[1]) & 0xFFFFFFFF

  def encrypt_block(self, L, R):
    for i in range(16):
      L = L ^ self.P[i]
      R = self.F(L) ^ R
      L, R = R, L
    L, R = R, L
    R = R ^ self.P[16]
    L = L ^ self.P[17]
    return L, R

  def decrypt_block(self, L, R):
    for i in range(17, 1, -1):
      L = L ^ self.P[i]
      R = self.F(L) ^ R
      L, R = R, L
    L, R = R, L
    R = R ^ self.P[1]
    L = L ^ self.P[0]
    return L, R

  def encrypt(self, plaintext):
    L = int.from_bytes(plaintext[:4].encode(), byteorder='big')
    R = int.from_bytes(plaintext[4:].encode(), byteorder='big')
    L, R = self.encrypt_block(L, R)
    return (L.to_bytes(4, byteorder='big') + R.to_bytes(4,byteorder='big')).hex()
```

```
    def decrypt(self, ciphertext):
        ciphertext = bytes.fromhex(ciphertext)
        L = int.from_bytes(ciphertext[:4], byteorder='big')
        R = int.from_bytes(ciphertext[4:], byteorder='big')
        L, R = self.decrypt_block(L, R)
        return (L.to_bytes(4, byteorder='big') + R.to_bytes(4,byteorder='big')).decode()

def main():
    key = "simplekey"
    plaintext = "hello123"
    blowfish = Blowfish(key)
    print(f"Plaintext: {plaintext}")
    encrypted_text = blowfish.encrypt(plaintext)
    print(f"Encrypted text: {encrypted_text}")
    decrypted_text = blowfish.decrypt(encrypted_text)
    print(f"Decrypted text: {decrypted_text}")

if __name__ == "__main__":
    main()
```

<u>Output</u> –

```
Plaintext: hello123
Encrypted text: eb392a471bd465ea
Decrypted text: hello123
```

<u>Conclusion</u> –

Hence, we have successfully implemented Blowfish algorithm.

Practical 6

Aim – To write a program to implement AES algorithm.

Theory –

The Advanced Encryption Standard (AES) is a symmetric block cipher adopted by the U.S. government as a standard for encrypting sensitive but unclassified information.

It's considered to be highly secure due to its complexity and the absence of any known practical attacks against it.

AES Algorithm Overview

AES operates on 128-bit blocks of data, and uses a 128-, 192-, or 256-bit key. The encryption process involves a series of rounds, each consisting of four transformations:

1. **SubBytes:** Replaces each byte in the block with a new byte from a substitution table.
2. **ShiftRows:** Cyclically shifts each row of the block by a certain number of positions.
3. **MixColumns:** Performs a matrix multiplication on each column of the block.
4. **AddRoundKey:** XORs the block with a round key derived from the main key.

The number of rounds depends on the key length: 10 rounds for 128-bit keys, 12 rounds for 192-bit keys, and 14 rounds for 256-bit keys.

Key Expansion

Before the encryption process begins, the main key is expanded into a series of round keys. This is done using a key schedule algorithm that involves a combination of rotations, substitutions, and XOR operations.

Implementation Considerations

When implementing AES, several factors need to be considered:

- **Key Length:** Choose the appropriate key length based on the security requirements of your application.
- **Mode of Operation:** AES is a block cipher, so it needs to be used in a mode of operation like Electronic Codebook (ECB), Cipher Block Chaining (CBC), Counter (CTR), etc.
- **Padding:** If the plaintext length is not a multiple of the block size, padding is required. Common padding schemes include PKCS#7 and Zero Padding.
- **Performance:** The efficiency of the implementation depends on various factors, such as the programming language, the optimization techniques used, and the hardware capabilities of the system.

Program –

```
# Simplified S-box for AES
s_box = [
```

```
    0x63, 0x7c, 0x77, 0x7b, 0xf2, 0x6b, 0x6f, 0xc5,
    0x30, 0x01, 0x67, 0x2b, 0xfe, 0xd7, 0xab, 0x76,
    0xca, 0x82, 0xc9, 0x7d, 0xfa, 0x59, 0x47, 0xf0,
    0xad, 0xd4, 0xa2, 0xaf, 0x9c, 0xa4, 0x72, 0xc0,
    0xb7, 0xfd, 0x93, 0x26, 0x36, 0x3f, 0xf7, 0xcc,
    0x34, 0xa5, 0xe5, 0xf1, 0x71, 0xd8, 0x31, 0x15,
    0x04, 0xc7, 0x23, 0xc3, 0x18, 0x96, 0x05, 0x9a,
    0x07, 0x12, 0x80, 0xe2, 0xeb, 0x27, 0xb2, 0x75,
    0x09, 0x83, 0x2c, 0x1a, 0x1b, 0x6e, 0x5a, 0xa0,
    0x52, 0x3b, 0xd6, 0xb3, 0x29, 0xe3, 0x2f, 0x84,
    0x53, 0xd1, 0x00, 0xed, 0x20, 0xfc, 0xb1, 0x5b,
    0x6a, 0xcb, 0xbe, 0x39, 0x4a, 0x4c, 0x58, 0xcf,
    0xd0, 0xef, 0xaa, 0xfb, 0x43, 0x4d, 0x33, 0x85,
    0x45, 0xf1, 0x7d, 0x22, 0xb6, 0xbf, 0x12, 0x98,
    0x48, 0xa9, 0xa7, 0xa4, 0xf5, 0x4b, 0xa0, 0xe8
]

def substitute_bytes(byte, s_box):
    """Substitute bytes using the given S-box."""
    if 0 <= byte < len(s_box):
        return s_box[byte]
    else:
        raise IndexError("Byte value is out of range for substitution.")

def add_round_key(state, round_key):
    """Add round key to state (XOR operation)."""
    return [s ^ k for s, k in zip(state, round_key)]

def aes_encrypt(plaintext, key):
    """Encrypt plaintext using a simplified AES-like algorithm."""
    key = [ord(c) for c in key]
    plaintext = [ord(c) for c in plaintext]

    # Ensure plaintext length is a multiple of 16
    while len(plaintext) % 16 != 0:
        plaintext.append(0)  # Pad with zeroes

    encrypted_text = ""

    # Process 16-byte blocks
    for i in range(0, len(plaintext), 16):
        block = plaintext[i:i+16]
        state = block

        # Step 1: Add round key (XOR with key)
        state = add_round_key(state, key)

        # Step 2: Substitute bytes using S-box
        try:
            state = [substitute_bytes(b, s_box) for b in state]
        except IndexError as e:
            print(f"ERROR! {e}")
```

```python
            return None

        # Convert to encrypted characters
        encrypted_text += ''.join(chr(b) for b in state)

    return encrypted_text

def aes_decrypt(ciphertext, key):
    """Decrypt ciphertext (reverse of simplified encryption)."""
    key = [ord(c) for c in key]
    ciphertext = [ord(c) for c in ciphertext]

    decrypted_text = ""

    # Process 16-byte blocks
    for i in range(0, len(ciphertext), 16):
        block = ciphertext[i:i+16]
        state = block

        # Step 1: Reverse Substitute bytes using S-box (reverse process)
        state = [s_box.index(b) for b in state]

        # Step 2: Reverse Add round key (XOR with key)
        state = add_round_key(state, key)

        # Convert to decrypted characters
        decrypted_text += ''.join(chr(b) for b in state)

    return decrypted_text.strip('\x00')  # Remove padding

def main():
    key = input("Enter a 16-character key: ")
    if len(key) != 16:
        print("Key must be exactly 16 characters!")
        return

    plaintext = input("Enter the message to encrypt (max 16 characters): ")
    if len(plaintext) > 16:
        print("Message should not exceed 16 characters.")
        return

    print(f"\nPlain text: {plaintext}")

    # Encryption
    encrypted_text = aes_encrypt(plaintext, key)
    if encrypted_text is None:
        return
    print(f"Encrypted text: {''.join(hex(ord(c))[2:] for c in encrypted_text)}")

    # Decryption
    decrypted_text = aes_decrypt(encrypted_text, key)
    print(f"Decrypted text: {decrypted_text}")
```

```
if __name__ == "__main__":
    main()
```

Output –

```
Enter a 16-character key: 1234abcd1234abcd
Enter the message to encrypt (max 16 characters): helloworld

Plain text: helloworld
Encrypted text: cb5bcf6aab59fe474cb1c318efaafb43
Decrypted text: helloworld
```

Conclusion –

Hence, we have successfully implemented AES algorithm.

Practical 7

Aim – To write a program to implement Diffie-Hellman key exchange technique for symmetric Cryptography.

Theory –

The Diffie-Hellman key exchange is a cryptographic protocol used to establish a shared secret between two parties over an insecure channel.

This shared secret can then be used to encrypt subsequent communications using a symmetric encryption algorithm.

Key Concepts

- **Public Key Cryptography:** Unlike symmetric encryption, which uses the same key for both encryption and decryption, public key cryptography uses a pair of keys: a public key and a private key. The public key can be freely shared, while the private key must be kept secret.
- **Modular Arithmetic:** Diffie-Hellman relies on modular arithmetic, which involves performing arithmetic operations within a specific range (a modulus).

The Diffie-Hellman Protocol

1. **Agreement on Public Parameters:** Both parties agree on two publicly known values:
   - **Prime number:** A large prime number, denoted as p.
   - **Generator:** A number g that is a primitive root modulo p.
2. **Generation of Private Keys:** Each party generates a random private key:
   - **Alice:** Generates a random private key a.
   - **Bob:** Generates a random private key b.
3. **Calculation of Public Values:**
   - **Alice:** Calculates her public value A = g^a mod p and sends it to Bob.
   - **Bob:** Calculates his public value B = g^b mod p and sends it to Alice.
4. **Calculation of Shared Secret:**
   - **Alice:** Calculates the shared secret s = B^a mod p.
   - **Bob:** Calculates the shared secret s = A^b mod p.

Security

The security of Diffie-Hellman relies on the discrete logarithm problem, which is computationally difficult to solve. This problem involves finding the exponent x in the equation g^x = y mod p.

Program –

```
import random

# Function to generate a prime number
def generate_prime():
    # Using a simple method to generate a prime number
    prime_candidates = [17, 19, 23, 29, 31, 37, 41, 43, 47]
    return random.choice(prime_candidates)

# Function to generate a primitive root
def generate_primitive_root(prime):
    roots = []
    for g in range(2, prime):
        if len(set(pow(g, powers, prime) for powers in range(1, prime))) == prime - 1:
            roots.append(g)
    return random.choice(roots)

# Function to compute the shared secret
def diffie_hellman(private_key_a, private_key_b, prime, primitive_root):
    public_key_a = pow(primitive_root, private_key_a, prime)
    public_key_b = pow(primitive_root, private_key_b, prime)

    shared_secret_a = pow(public_key_b, private_key_a, prime)
    shared_secret_b = pow(public_key_a, private_key_b, prime)

    return shared_secret_a, shared_secret_b

# Simple XOR encryption/decryption function
def xor_encrypt_decrypt(message, key):
    return ''.join(chr(ord(c) ^ key) for c in message)

def main():
    # Generate prime and primitive root
    prime = generate_prime()
    primitive_root = generate_primitive_root(prime)

    print(f"Prime: {prime}, Primitive Root: {primitive_root}")

    # User inputs for private keys
    private_key_a = int(input("User A, enter your private key: "))
    private_key_b = int(input("User B, enter your private key: "))

    # Compute the shared secret
    shared_secret_a, shared_secret_b = diffie_hellman(private_key_a, private_key_b, prime, primitive_root)

    print(f"Shared Secret (User A): {shared_secret_a}")
    print(f"Shared Secret (User B): {shared_secret_b}")

    # Use the shared secret as a symmetric key (simplified for demonstration)
    symmetric_key = shared_secret_a % 256  # Use modulo to keep key in byte range
    print(f"Symmetric Key: {symmetric_key}")

    # Encrypt and decrypt a message
```

```
    message = input("Enter a message to encrypt: ")
    encrypted_message = xor_encrypt_decrypt(message, symmetric_key)
    print(f"Encrypted Message: {encrypted_message}")

    decrypted_message = xor_encrypt_decrypt(encrypted_message, symmetric_key)
    print(f"Decrypted Message: {decrypted_message}")

if __name__ == "__main__":
    main()
```

<u>Output</u> –

```
Prime: 19, Primitive Root: 10
User A, enter your private key: 6
User B, enter your private key: 8
Shared Secret (User A): 7
Shared Secret (User B): 7
Symmetric Key: 7
Enter a message to encrypt: Hello
Encrypted Message: Obkkh
Decrypted Message: Hello
```

<u>Conclusion</u> –

Hence, we have successfully implemented Diffie-Hellman key exchange technique for symmetric Cryptography.

Practical 8

Aim – To write a program to implement RSA Algorithm.

Theory –

RSA (Rivest-Shamir-Adleman) is one of the most widely used public-key cryptographic algorithms. It provides a method for secure communication by using a pair of keys: a public key and a private key. The public key is freely distributed, while the private key remains secret.

Key Generation:

1. **Choose two large prime numbers, p and q.** These numbers should be kept secret.
2. **Calculate the modulus, n:** n = p * q
3. **Calculate Euler's totient function, ϕ(n):** ϕ(n) = (p-1) * (q-1)
4. **Choose an integer e, 1 < e < ϕ(n), such that gcd(e, ϕ(n)) = 1.** This means e and ϕ(n) are relatively prime.
5. **Calculate the private key, d:** d ≡ e^-1 (mod ϕ(n)). This means d is the modular multiplicative inverse of e modulo ϕ(n).

Encryption:

To encrypt a message m:

1. Convert the message into a numerical representation (e.g., ASCII values).
2. Calculate the ciphertext c: c ≡ m^e (mod n)

Decryption:

To decrypt a ciphertext c:

1. Calculate the plaintext m: m ≡ c^d (mod n)
2. Convert the numerical representation back into the original message.

Security:

The security of RSA relies on the difficulty of factoring the modulus n into its prime factors p and q. This is a computationally intensive problem, even for large values of n. If an attacker could factor n, they could easily calculate the private key from the public key.

Applications:

RSA is used in various applications, including:

- **Secure communication:** For encrypting and decrypting messages.
- **Digital signatures:** For verifying the authenticity of digital documents.
- **Public key infrastructure (PKI):** For managing and distributing digital certificates.

Program –

```
import random

def generate_prime(bits=8):
    def is_prime(num):
        if num <= 1:
            return False
        for i in range(2, int(num**0.5) + 1):
            if num % i == 0:
                return False
        return True

    while True:
        num = random.getrandbits(bits)
        if is_prime(num):
            return num

def gcd(a, b):
    while b:
        a, b = b, a % b
    return a

def mod_inverse(e, phi):
    m0, x0, x1 = phi, 0, 1
    if phi == 1:
        return 0
    while e > 1:
        q = e // phi
        t = phi
        phi = e % phi
        e = t
        t = x0
        x0 = x1 - q * x0
        x1 = t
    # Make x1 positive
    if x1 < 0:
        x1 += m0
    return x1

def generate_keys():
    p = generate_prime()
    q = generate_prime()
    n = p * q
    phi = (p - 1) * (q - 1)
    e = 65537
    d = mod_inverse(e, phi)
    return (e, n), (d, n)

def encrypt(plaintext, public_key):
    e, n = public_key
    ciphertext = [pow(ord(char), e, n) for char in plaintext]
```

```
    return ciphertext

def decrypt(ciphertext, private_key):
    d, n = private_key
    plaintext = ''.join([chr(pow(char, d, n)) for char in ciphertext])
    return plaintext

def main():
    public_key, private_key = generate_keys()
    print(f"Public Key: {public_key}")
    print(f"Private Key: {private_key}")
    plaintext = input("Enter the Plaintext: ").strip()
    print(f"Plaintext: {plaintext}")

    ciphertext = encrypt(plaintext, public_key)
    print(f"Encrypted text: {ciphertext}")

    decrypted_text = decrypt(ciphertext, private_key)
    print(f"Decrypted text: {decrypted_text}")

if __name__ == "__main__":
    main()
```

<u>Output</u> –

```
Public Key: (65537, 11461)
Private Key: (6497, 11461)
Enter the Plaintext: Hello
Plaintext: Hello
Encrypted text: [5474, 5197, 3529, 3529, 8662]
Decrypted text: Hello
```

<u>Conclusion</u> –

Hence, we have successfully implemented RSA algorithm.

Practical 9

Aim – To write a program to implement signature and digital signature technique.

Theory –

A digital signature is a cryptographic technique that provides authenticity, integrity, and non-repudiation for digital data. It ensures that the data has not been altered since it was signed and that it originates from the claimed signer.

Components of a Digital Signature:

1. **Message:** The data to be signed.
2. **Hash function:** A cryptographic function that takes an input (the message) and produces a fixed-size output (the hash value).
3. **Private key:** The signer's private key, used to create the signature.
4. **Public key:** The signer's public key, used to verify the signature.

Digital Signature Process:

1. **Hashing:** The message is hashed using a cryptographically secure hash function (e.g., SHA-256).
2. **Signing:** The signer's private key is used to encrypt the hash value, creating the digital signature.
3. **Transmission:** The message and the digital signature are transmitted to the recipient.

Verification Process:

1. **Hashing:** The recipient hashes the received message using the same hash function.
2. **Decryption:** The recipient uses the signer's public key to decrypt the digital signature.
3. **Comparison:** The decrypted hash value is compared to the hash value calculated in step 1. If they match, the signature is valid.

Security Properties:

- **Authenticity:** The signature ensures that the message originated from the claimed signer.
- **Integrity:** The signature verifies that the message has not been altered since it was signed.
- **Non-repudiation:** The signer cannot deny having signed the message.

Applications:

- **Email:** To verify the authenticity of email messages.
- **Digital documents:** To ensure the integrity and authenticity of electronic documents.
- **Secure communication:** To protect the confidentiality and integrity of data transmitted over a network.
- **Digital certificates:** To authenticate individuals, organizations, and devices.

Program –

```
import hashlib
import random

def create_signature(message, secret_key):
    message_hash = hashlib.sha256(message.encode()).hexdigest()
    signature = message_hash + secret_key
    return signature

def verify_signature(message, secret_key, signature):
    expected_signature = create_signature(message, secret_key)
    return expected_signature == signature

def generate_keys():
    private_key = random.randint(1, 100)
    public_key = private_key + 2
    return private_key, public_key

def rsa_sign(message, private_key):
    message_hash = hashlib.sha256(message.encode()).hexdigest()
    return message_hash + str(private_key)

def rsa_verify(message, signature, public_key):
    expected_signature = rsa_sign(message, public_key - 2)
    return expected_signature == signature

message = input("Enter the message: ")
secret_key = input("Enter your secret key: ")

simple_signature = create_signature(message, secret_key)
print(f"Simple Signature: {simple_signature}")

is_verified = verify_signature(message, secret_key, simple_signature)
print(f"Signature verified: {is_verified}")

private_key, public_key = generate_keys()
rsa_signature = rsa_sign(message, private_key)
print(f"RSA Signature: {rsa_signature}")

is_rsa_verified = rsa_verify(message, rsa_signature, public_key)
print(f"RSA Signature verified: {is_rsa_verified}")
```

Output –

```
Enter the message: hello
Enter your secret key: 123
Simple Signature: 2cf24dba5fb0a30e26e83b2ac5b9e29e1b161e5c1fa7425e7304336293
    8b9824123
Signature verified: True
RSA Signature: 2cf24dba5fb0a30e26e83b2ac5b9e29e1b161e5c1fa7425e73043362938b9
    82450
RSA Signature verified: True
```

Conclusion –

Hence, we have successfully implemented signature and digital signature technique.

<u>Practical 10</u>

<u>Aim</u> – To write a program to implement SHA algorithm.

<u>Theory</u> –

The Secure Hash Algorithm (SHA) is a family of cryptographic hash functions developed by the National Security Agency (NSA) of the United States.

These functions are designed to produce a fixed-size output (hash value) from any given input message.

The hash value is used to verify the integrity of the message, ensuring that it has not been altered or tampered with.

The SHA family includes several variants, each with a different output size:

- SHA-1: Produces a 160-bit hash value.
- SHA-224: Produces a 224-bit hash value.
- SHA-256: Produces a 256-bit hash value.
- SHA-384: Produces a 384-bit hash value.
- SHA-512: Produces a 512-bit hash value.

All SHA algorithms are based on the same underlying principle: they break the input message into 512-bit blocks, and then apply a series of mathematical operations to each block to produce a hash value.

These operations include:

- **Message Padding**: If the input message is not a multiple of 512 bits, it is padded with zeros and a single bit set to 1.
- **Block Processing**: Each 512-bit block is processed through a series of rounds. In each round, the block is combined with a chaining variable, which is updated with the output of the round.
- **Output Generation**: After all blocks have been processed, the final chaining variable is the hash value.

The specific mathematical operations used in SHA algorithms are complex and involve various bitwise operations, arithmetic operations, and logical operations.

The goal of these operations is to create a function that is resistant to collisions, meaning that it is unlikely that two different input messages will produce the same hash value.

SHA algorithms are widely used in various applications, including digital signatures, password hashing, and data integrity verification.

They are considered to be secure, but it is important to use the appropriate variant for the specific application.

For example, SHA-1 is no longer considered secure due to the discovery of collision attacks, and it is recommended to use SHA-2 or SHA-3 instead.

Program –

```
import hashlib

def calculate_sha256(input_string):
    # Create a SHA-256 hash object
    sha256_hash = hashlib.sha256()

    # Update the hash object with the bytes of the input string
    sha256_hash.update(input_string.encode('utf-8'))

    # Return the hexadecimal representation of the hash
    return sha256_hash.hexdigest()

# Get user input
user_input = input("Enter a string to hash with SHA-256: ")

# Calculate and display the SHA-256 hash
hash_result = calculate_sha256(user_input)
print(f"SHA-256 Hash: {hash_result}")
```

Output –

```
Enter a string to hash with SHA-256: Hello
SHA-256 Hash: 185f8db32271fe25f561a6fc938b2e264306ec304eda518007d17648263819
    69
```

Conclusion –

Hence, we have successfully implemented SHA algorithm.