Ex.No.10
30.09.24

IMPLEMENTATION OF DIGITAL SIGNATURE STANDARD

AIM:

To implement key generation, signature generation and verification using Digital Signature Standard.

ALGORITHM:

Step 1: Key Generation:

1. **Input the prime p** from the user.
2. **Compute q**:
    - Use the formula q = (p - 1) / 2.
    - If q is not prime, print an error and exit the process.
3. **Generate the generator g**:
    - Use the formula g = h^((p - 1) / q) mod p.
    - Ensure g > 1, and retry until a valid g is found.
4. **Input the private key x**:
    - Ask the user to input x such that 0 < x < q.
    - If x is not in this range, print an error and exit.
5. **Compute the public key y**:
    - Use the formula y = g^x mod p.
6. **Output the generated keys**:
    - Print the values of p, q, g, x, and y.

Step 2: File Signing:

1. **Input the file path** for the file to be signed.
2. **Read the file** and convert its content to a byte array.
3. **Hash the file data** using a simple hash function:
    - Multiply each byte by 31 and sum them up.

4. **Generate a random integer k**:
    - Ensure 0 < k < q.
5. **Compute the signature (r, s)**:
    - Calculate r = (g^k mod p) mod q.
    - Compute the hash h of the file.
    - Calculate s = (k^-1 * (h + x * r)) mod q.
6. **Output the signature**:
    - Print the values of r and s.

Step 3: Signature Verification:

1. **Input the file path** for the file to be verified.
2. **Input the signature (r, s)**:
    - Use the signature generated during the signing process.
3. **Verify the signature values**:
    - Ensure that 0 < r < q and 0 < s < q. If not, return invalid.
4. **Read the file** and convert its content to a byte array.
5. **Hash the file data** to get h.
6. **Compute the verification values**:
    - Calculate w = s^-1 mod q.
    - Calculate u1 = (h * w) mod q and u2 = (r * w) mod q.
    - Compute v = ((g^u1 mod p) * (y^u2 mod p) mod p) mod q.
7. **Compare v and r**:
    - If v == r, the signature is valid.
    - Otherwise, the signature is invalid.
8. **Output the verification result**:
    - Print whether the signature is valid or invalid.

`

CODING:

DigitalSignature.java:

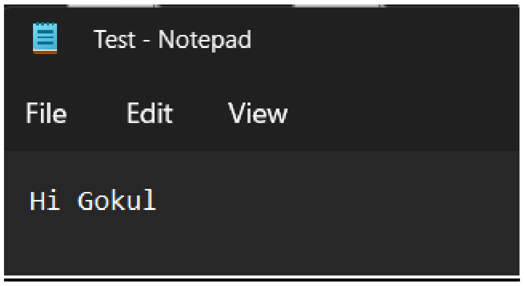
```
import java.io.IOException;
import java.math.BigInteger;
import java.nio.file.Files;
import java.nio.file.Paths;
import java.security.MessageDigest;
import java.security.NoSuchAlgorithmException;
import java.security.SecureRandom;
import java.util.Scanner;
public class DigitalSignature {
   private static boolean isPrime(int num) {
      if (num < 2)
         return false;
      for (int i = 2; i < num / 2; i++) {
         if (num % 2 == 0)
            return false;
      }
      return true;
   }
   private static BigInteger primeDivisor(BigInteger num) {
      for (BigInteger i = new BigInteger("101"); i.compareTo(num.subtract(BigInteger.ONE)) < 0; i =
i.add(BigInteger.ONE)) {
         if (num.mod(i).equals(BigInteger.ZERO) && isPrime(i.intValue())) {
            return i;
         }
      }
      return null;
   }
    private static BigInteger[] keyGen() {
      Scanner s = new Scanner(System.in);
      System.out.print("Enter The Prime (p):");
      BigInteger p = s.nextBigInteger();
      if (!isPrime(p.intValue())) {
         System.out.println("P is not Prime.!");
         return null;
      }
      BigInteger q = primeDivisor(p.subtract(BigInteger.ONE));
      BigInteger h = new BigInteger(p.bitLength(), new
SecureRandom()).mod(p.subtract(BigInteger.ONE)).add(BigInteger.ONE);
      BigInteger g = h.modPow(p.subtract(BigInteger.ONE).divide(q), p);
      BigInteger x = new BigInteger(q.bitLength(), new
SecureRandom()).mod(q.subtract(BigInteger.ONE)).add(BigInteger.ONE);
      BigInteger y = g.modPow(x, p);
      System.out.print("Generated Keys: p=" + p + ",q=" + q + ",h=" + h + ",g=" + g + ",x=" + x + ",y=" + y);
      return new BigInteger[] { p, q, h, g, x, y };
   }
```

```
    private static BigInteger[] SignGen(BigInteger p, BigInteger q, BigInteger g, BigInteger x, BigInteger HashMsg) {
        BigInteger k = new BigInteger(q.bitLength(), new
SecureRandom()).mod(q.subtract(BigInteger.ONE)).add(BigInteger.ONE);
        BigInteger r = g.modPow(k, p).mod(q);
        BigInteger s = k.modInverse(q).multiply(HashMsg.add(x.multiply(r))).mod(q);
        return new BigInteger[] { r, s };
    }
    private static void SignVerification(BigInteger p, BigInteger q, BigInteger g, BigInteger r, BigInteger s,
            BigInteger y, BigInteger hashMsg) {
        BigInteger w = s.modInverse(q);
        BigInteger u1 = hashMsg.multiply(w).mod(q);
        BigInteger u2 = r.multiply(w).mod(q);
        BigInteger v = (g.modPow(u1, p).multiply(y.modPow(u2, p))).mod(p).mod(q);
        if (v.equals(r)) {
            System.out.println("Signature Verified Successfully.");
        } else {
            System.out.println("Signature Verification Failed.");
        }
    }
    private static BigInteger hashMsg(String msg) {
        try {
            MessageDigest md = MessageDigest.getInstance("SHA-256");
            byte[] hashBytes = md.digest(msg.getBytes());
            return new BigInteger(hashBytes);
        } catch (NoSuchAlgorithmException e) {
            throw new RuntimeException(e);
        }
    }
    private static BigInteger HashReadFile(String filePath) {
        try {
            String content = new String(Files.readAllBytes(Paths.get(filePath)));
            return hashMsg(content);
        } catch (IOException e) {
            System.out.println("File Not Found.!");
            return null;
        }
    }
    public static void main(String[] args) {
        BigInteger p = null, q = null, h = null, g = null, x = null, y = null;
        Scanner s = new Scanner(System.in);
        int choice;
        do {
            System.out.println("\nMENU.");
            System.out.println("1->Key Generation.");
            System.out.println("2->Signature Generation (File).");
            System.out.println("3->Signature Verification (File).");
            System.out.println("4->Signature Generation (Message).");
            System.out.println("5->Signature Verification (Message).");
            System.out.println("6->Exit.");
System.out.print("Enter Your Choice:");
choice = s.nextInt();
switch (choice) {
  case 1:
    BigInteger[] keys = keyGen();
    if (keys != null) {
      p = keys[0];
      q = keys[1];
      h = keys[2];
      g = keys[3];
      x = keys[4];
      y = keys[5];
    }
    break;
  case 2:
    if (p == null || q == null || h == null || g == null || x == null || y == null) {
      System.out.println("Keys Are Not Generated Yet.Generate Keys First.!");
      continue;
    }
    System.out.print("Enter The File Path For Signature Generation:");
    s.nextLine();
    String path = s.nextLine();
    BigInteger filehash = HashReadFile(path);
    if (filehash != null) {
      BigInteger[] signs = SignGen(p, q, g, x, filehash);
      System.out.println("Generated Signature: r=" + signs[0] + ",s=" + signs[1]);
    }
    break;
  case 3:
    if (p == null || q == null || h == null || g == null || x == null || y == null) {
      System.out.println("Keys Are Not Generated Yet.Generate Keys First.!");
      continue;
    }
    System.out.print("Enter The File Path For Signature Verification:");
    s.nextLine();
    String vpath = s.nextLine();
    BigInteger vfilehash = HashReadFile(vpath);
    if (vfilehash != null) {
      System.out.print("Enter r:");
      BigInteger r = s.nextBigInteger();
      System.out.print("Enter s:");
      BigInteger S = s.nextBigInteger();
      SignVerification(p, q, g, r, S, y, vfilehash);
    }
    break;
  case 4:
    if (p == null || q == null || g == null || y == null || x == null) {
      System.out.println("Keys not generated yet. Please generate keys first.");
      continue;
```

```
                }

                System.out.print("Enter the message to sign: ");
                s.nextLine(); // Consume the newline
                String message = s.nextLine();
                BigInteger messageHash = hashMsg(message);
                BigInteger[] messageSignature = SignGen(p,q,g,x,messageHash);
                System.out.println("Generated Signature for Message: r=" + messageSignature[0] + ", s=" +
messageSignature[1]);
                break;
              case 5:
                if (p == null || q == null || g == null || y == null) {
                  System.out.println("Keys not generated yet. Please generate keys first.");
                  continue;
                }

                System.out.print("Enter the message for verification: ");
                s.nextLine(); // Consume the newline
                String verifyMessage = s.nextLine();
                BigInteger verifyMessageHash = hashMsg(verifyMessage);
                System.out.print("Enter r: ");
                BigInteger rMsg = s.nextBigInteger();
                System.out.print("Enter s: ");
                BigInteger sMsg = s.nextBigInteger();
                SignVerification(p, q, g, rMsg, sMsg, y, verifyMessageHash);
                break;
              case 6:
                System.out.println("Exiting...");
                break;

              default:
                System.out.println("Invalid choice. Please select a valid option.");
            }

        } while (choice != 6);
        s.close();
    }
}
```

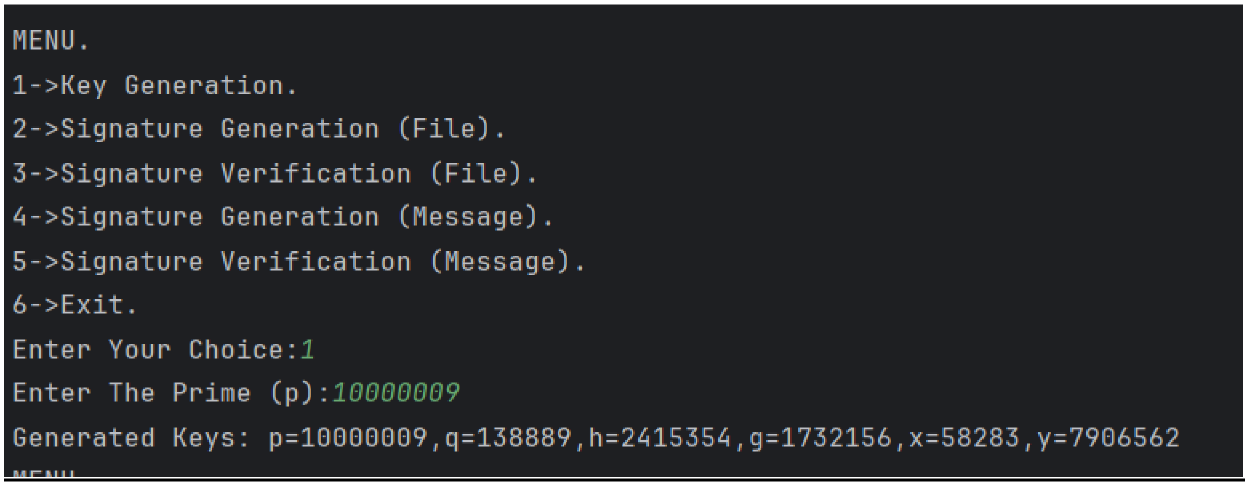
SCREEN SHOTS:

Test.txt:



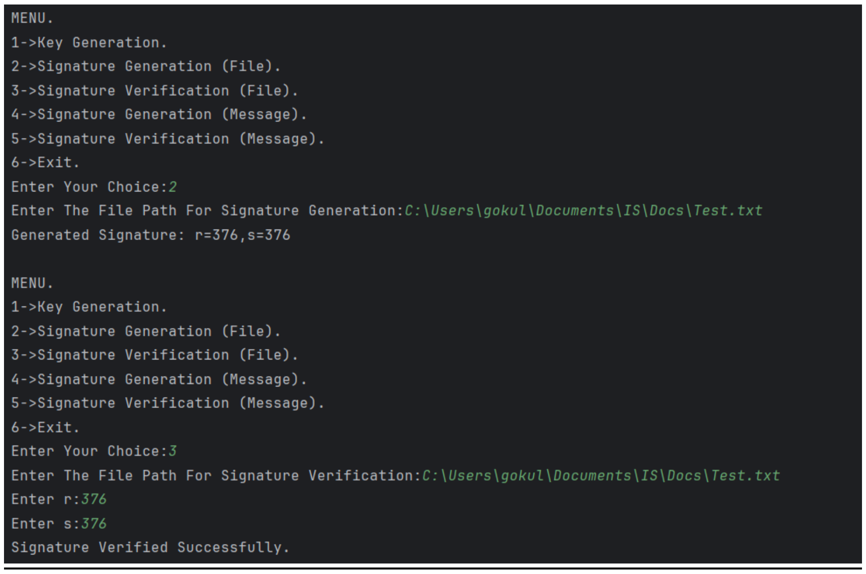
```
Hi Gokul
```

Key Generation:



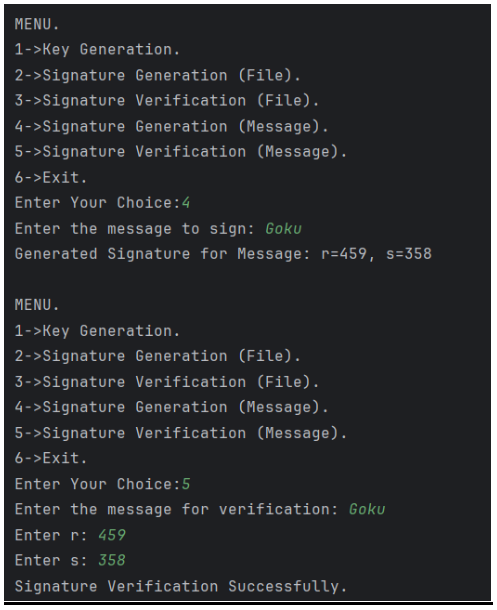
```
MENU.
1->Key Generation.
2->Signature Generation (File).
3->Signature Verification (File).
4->Signature Generation (Message).
5->Signature Verification (Message).
6->Exit.
Enter Your Choice:1
Enter The Prime (p):10000009
Generated Keys: p=10000009,q=138889,h=2415354,g=1732156,x=58283,y=7906562
```

Signing And Verification of a File:



```
MENU.
1->Key Generation.
2->Signature Generation (File).
3->Signature Verification (File).
4->Signature Generation (Message).
5->Signature Verification (Message).
6->Exit.
Enter Your Choice:2
Enter The File Path For Signature Generation:C:\Users\gokul\Documents\IS\Docs\Test.txt
Generated Signature: r=376,s=376

MENU.
1->Key Generation.
2->Signature Generation (File).
3->Signature Verification (File).
4->Signature Generation (Message).
5->Signature Verification (Message).
6->Exit.
Enter Your Choice:3
Enter The File Path For Signature Verification:C:\Users\gokul\Documents\IS\Docs\Test.txt
Enter r:376
Enter s:376
Signature Verified Successfully.
```

Signing And Verification of a Message:



```
MENU.
1->Key Generation.
2->Signature Generation (File).
3->Signature Verification (File).
4->Signature Generation (Message).
5->Signature Verification (Message).
6->Exit.
Enter Your Choice:4
Enter the message to sign: Goku
Generated Signature for Message: r=459, s=358

MENU.
1->Key Generation.
2->Signature Generation (File).
3->Signature Verification (File).
4->Signature Generation (Message).
5->Signature Verification (Message).
6->Exit.
Enter Your Choice:5
Enter the message for verification: Goku
Enter r: 459
Enter s: 358
Signature Verification Successfully.
```

RESULT:

Thus, implemented key generation, signature generation and verification using Digital Signature Standard.

Evaluation

Parameter	Max Marks	Marks Obtained
Uniqueness of the Code	50	
Completion of experiment on time	10	
Documentation	15	
Total	75	
Signature of the faculty with Date		