Experiment No. 3

Title: A5/1

Batch: B3 **Roll No.: 16010420099** **Experiment No.: 03**

Aim: To implement stream cipher A5/1

Resources needed: Windows/Linux

Theory: Pre Lab/ Prior Concepts:
A5/1 employs three linear feedback shifl registers , or LFSRs, whichare labeled X, Y, and Z. Register X holds 19 bits, (x_0,x_1…x_{18}).The register Y holds 22 bits, (y_0,y_1…y_{21}) and Z holds 23 bits, (z_0,y_1…z_{22})·Of course, all computer geeks love powers of two, so it's no accident that the three LFSRs hold a total of 64 bits.
Not coincidentally, the A5/1 key K is also 64 bits. The key is used as the initial fill of the three registers, that is, the key is used as the initial values in the three registers. After these three registers are filled with the key,1 we are ready to generate the keystream. But before we can describe how the keystream is generated, we need to say a little more about the registers X, Y, and Z.
When register X steps, the following series of operations occur:

$$t = x_{13} \oplus x_{16} \oplus x_{17} \oplus x_{18}$$
$$x_i = x_{i-1} \text{ for } i = 18, 17, 16, \ldots, 1$$
$$x_0 = t$$

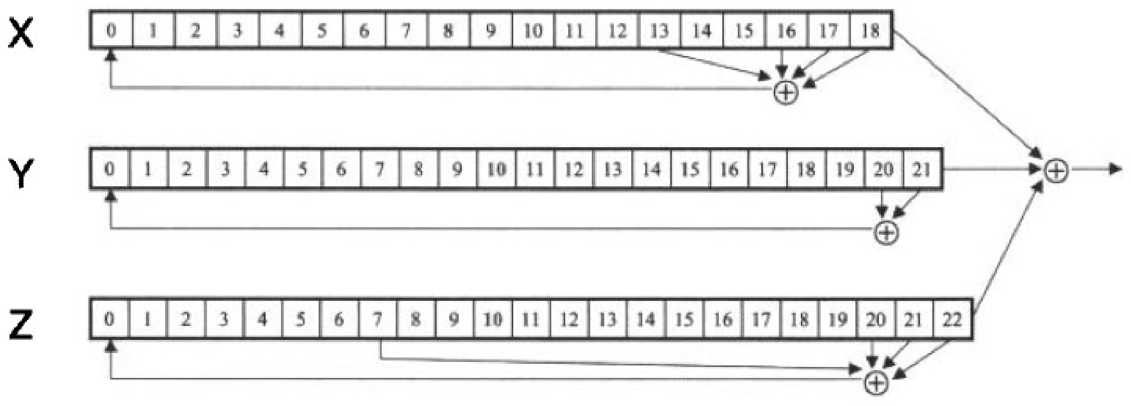
Similarly, for registers Y and Z, each step consists of

$$t = y_{20} \oplus y_{21}$$
$$y_i = y_{i-1} \text{ for } i = 21, 20, 19 \ldots, 1$$
$$y_0 = t$$

and

$$t = z_7 \oplus z_{20} \oplus z_{21} \oplus z_{22}$$
$$z_i = z_{i-1} \text{ for } i = 22, 21, 20, \ldots, 1$$
$$z_0 = t$$

respectively.
Given three bits x, y, and z, define ma,](x,y, z) to be the majority vote function, that is, if the majority of x, y, and z are 0, the function returns 0; otherwise it returns 1. Since there are an odd number of bits, there cannot be a tie, so this function is well defined.
The wiring diagram for the A5/1 algorithm is illustrated below:



A5/1 Keystream Generator

Procedure / Approach /Algorithm / Activity Diagram:

A. Key Stream generation Algorithm:

At each step: m = maj(x_8, y_{10}, z_{10})

-Examples: maj(0,1,0) = 0 and maj(1,1,0) = 1

If x_8 = m then X steps

-$t = x_{13} \oplus x_{16} \oplus x_{17} \oplus x_{18}$

-$x_i = x_{i-1}$ for i = 18,17,…,1 and $x_0 = t$

If y_{10} = m then Y steps

-$t = y_{20} \oplus y_{21}$

-$y_i = y_{i-1}$ for i = 21,20,…,1 and $y_0 = t$

If z_{10} = m then Z steps

-$t = z_7 \oplus z_{20} \oplus z_{21} \oplus z_{22}$

-$z_i = z_{i-1}$ for i = 22,21,…,1 and $z_0 = t$

Keystreambit is $x_{18} \oplus y_{21} \oplus z_{22}$

Implementation:

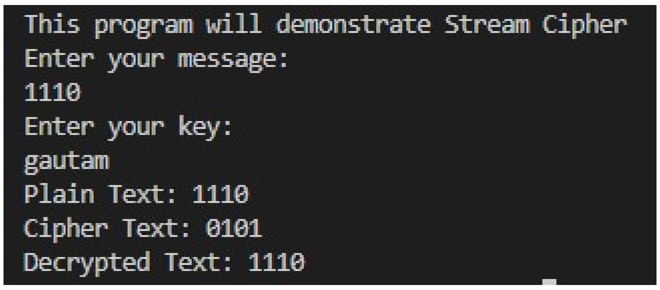
Implement the A5/1 algorithm.Encryption and decryption function should ask for key and a input and show the output to the user.

Results: (Program with output as per the format)

```
public class Binary {
    public static String convertTextToBinaryString(String text) {
        String binaryString = "";
        for (char c : text.toCharArray()) binaryString +=
Integer.toBinaryString(c);
        return binaryString;
    }

    public static String convertBinaryStringToText(String binaryString)
{
        String text = "";
        String[] bytes = binaryString.split("(?<=\\G.{7})");
        for (String textByte : bytes) text += (char)
Integer.parseInt(textByte, 2);
```

```java
        return text;
    }

    public static char XOR(char a, char b) {
        if (a == b) return '0';
        else return '1';
    }

    public static char maxBit(char a, char b) {
        return a > b ? a : b;
    }
}

public class LFSR {
    private char[] bits; // LSB is at the starting index, NOT at the
end
    private int clockingBit;
    private int[] tappedBits;

    LFSR(int _numberOfBits, int _clockingBit, int[] _tappedBits) {
        // Initialize with all zeroes
        bits = new char[_numberOfBits];
        for (int i = 0; i < _numberOfBits; i++) bits[i] = '0';
        clockingBit = _clockingBit;
        tappedBits = _tappedBits;
    }

    LFSR(char[] _bits, int _clockingBit, int[] _tappedBits) {
        bits = _bits;
        clockingBit = _clockingBit;
        tappedBits = _tappedBits;
    }

    void setBits(char[] _bits) {
        bits = _bits;
    }

    char getClockingBit() {
        // Will return the clocking bit
        return bits[clockingBit];
    }

    char clock() {
        // Will perform the clocking mechanism and
        // return the output bit
        char inputBit = '0';
        for (int bitIndex : tappedBits)
            inputBit = XOR(inputBit, bits[bitIndex]);

        char outputBit = bits[bits.length-1];
        for (int i = bits.length - 1; i > 0; i--)
            bits[i] = bits[i-1];

        bits[0] = inputBit;
        return outputBit;
    }
}

public class KeyGenerator {
    private LFSR x = new LFSR(19, 8, new int[] {18, 17, 16, 13});
    private LFSR y = new LFSR(22, 10, new int[] {20, 21});
    private LFSR z = new LFSR(23, 10, new int[] {22, 21, 20, 7});
    KeyGenerator(char[] key) {
        char[] xBits = new char[19];
        char[] yBits = new char[22];
        char[] zBits = new char[23];
        System.arraycopy(key, 0, xBits, 0, 19);
        System.arraycopy(key, 19, yBits, 0, 22);
        System.arraycopy(key, 22, zBits, 0, 23);
        x.setBits(xBits);
        y.setBits(yBits);
        z.setBits(zBits);
    }

    public char getNextKeyBit() {
        char xClockingBit = x.getClockingBit();
        char yClockingBit = y.getClockingBit();
        char zClockingBit = z.getClockingBit();
        char maxClockingBit = maxBit(xClockingBit, maxBit(yClockingBit,
zClockingBit));
        char outputBit = '0';
        if (maxClockingBit == xClockingBit) outputBit = XOR(outputBit,
x.clock());
        if (maxClockingBit == yClockingBit) outputBit = XOR(outputBit,
y.clock());
        if (maxClockingBit == zClockingBit) outputBit = XOR(outputBit,
z.clock());
        return outputBit;
    }
}

import java.util.Scanner;
import static app.Binary.*;

public class StreamCipher {
    private String keyBinary;

    StreamCipher(String key) {
        keyBinary = "";
        keyBinary = convertTextToBinaryString(key);
        keyBinary = String.format("%64s", keyBinary).replace(' ', '0');
        if (keyBinary.length() > 64) keyBinary = keyBinary.substring(0,
64);
    }

    public String encrypt(String plaintext) {
        KeyGenerator generator = new
KeyGenerator(keyBinary.toCharArray());
        String plaintextBinary = convertTextToBinaryString(plaintext);
        char[] ciphertextBinary = plaintextBinary.toCharArray();
        for (int i = 0; i < ciphertextBinary.length; i++)
            ciphertextBinary[i] = XOR(ciphertextBinary[i],
generator.getNextKeyBit());
        return convertBinaryStringToText(new String(ciphertextBinary));
    }

    public String encryptBinary(String plaintext) {
        KeyGenerator generator = new
KeyGenerator(keyBinary.toCharArray());
        char[] ciphertext = plaintext.toCharArray();
        for (int i = 0; i < ciphertext.length; i++)
            ciphertext[i] = XOR(ciphertext[i],
generator.getNextKeyBit());
```

```
        return new String(ciphertext);
    }

    public String decrypt(String ciphertext) {
        KeyGenerator generator = new
KeyGenerator(keyBinary.toCharArray());
        String ciphertextBinary =
convertTextToBinaryString(ciphertext);
        char[] plaintextBinary = ciphertextBinary.toCharArray();
        for (int i = 0; i < plaintextBinary.length; i++)
            plaintextBinary[i] = XOR(plaintextBinary[i],
generator.getNextKeyBit());
        return convertBinaryStringToText(new String(plaintextBinary));
    }

    public String decryptBinary(String ciphertext) {
        KeyGenerator generator = new
KeyGenerator(keyBinary.toCharArray());
        char[] plaintext = ciphertext.toCharArray();
        for (int i = 0; i < plaintext.length; i++)
            plaintext[i] = XOR(plaintext[i],
generator.getNextKeyBit());
        return new String(plaintext);
    }

    public static void main(String[] args) {
        // Example key:
0101001000011010110001110001100100101001000000110111111010110111
        Scanner reader = new Scanner(System.in);

        System.out.println("This program will demonstrate Stream
Cipher");
        System.out.println("Enter your message:");
        String plaintext = reader.nextLine();
        System.out.println("Enter your key:");
        String key = reader.nextLine();
        StreamCipher cipher = new StreamCipher(key);

        String ciphertext = cipher.encryptBinary(plaintext);
        String decryptedtext = cipher.decryptBinary(ciphertext);

        System.out.println("Plain Text: " + plaintext);
        System.out.println("Cipher Text: " + ciphertext);
        System.out.println("Decrypted Text: " + decryptedtext);

        reader.close();
    }
}
```



```
This program will demonstrate Stream Cipher
Enter your message:
1110
Enter your key:
gautam
Plain Text: 1110
Cipher Text: 0101
Decrypted Text: 1110
```

Questions:

1) List the stream cipher used in current date along with the name of applications in which those are used.

ChaCha is the most widely used stream cipher in software due to its high speed in real-time applications. It is based on the Salsa20 cipher but it is improved. Google had selected ChaCha20 along with Bernstein's Poly1305 message authentication code in SPDY, which was intended as a replacement for TLS over TCP. ChaCha20 is also used for the arc4random random number generator in FreeBSD,[28] OpenBSD,[29] and NetBSD[30] operating systems. ChaCha20 usually offers better performance than the more prevalent Advanced Encryption Standard (AES) algorithm on systems where the CPU does not feature AES acceleration (such as the AES instruction set for x86 processors). As a result, ChaCha20 is sometimes preferred over AES in certain use cases involving mobile devices, which mostly use ARM-based CPUs.

Outcomes: CO2- Illustrate different cryptographic algorithms for security

Conclusion: (Conclusion to be based on the objectives and outcomes achieved)
Understood the class of stream ciphers and the A5/1 keystream cipher. Wrote a small program to demonstrate the same.

Grade: AA / AB / BB / BC / CC / CD /DD

Signature of faculty in-charge with date

References: Books/ Journals/ Websites:

1. Mark Stamp, “Information Security Principles and Practice”, Wiley.
2. Behrouz A. Forouzan, “Cryptography and Network Security”, Tata McGraw Hill
3. William Stalling, “Cryptography and Network Security”, Prentice Hall