Experiment No: 6 **Date:**

Error Detection

<u>AIM:</u> Implement Error Detection Mechanisms using

i) Checksum
ii) CRC

<u>THEORY:</u>

i) Error Detection using Checksum in Computer Networks:

- Error detection using checksum is a method employed in computer networks to ensure the integrity of transmitted data.
- It involves appending a checksum value to the data, which is calculated based on the content of the data itself.
- The receiver recalculates the checksum upon receiving the data and compares it with the transmitted checksum. If they match, the data is assumed to be intact; otherwise, errors are detected.

Real-World Use Case:

- Checksums are widely used in network protocols such as TCP/IP, UDP, and Ethernet.
- In TCP/IP, checksums are used at both the IP and TCP layers to ensure that data packets are transmitted without corruption.
- In Ethernet, a checksum called Frame Check Sequence (FCS) is used to detect errors in frames transmitted over the network.

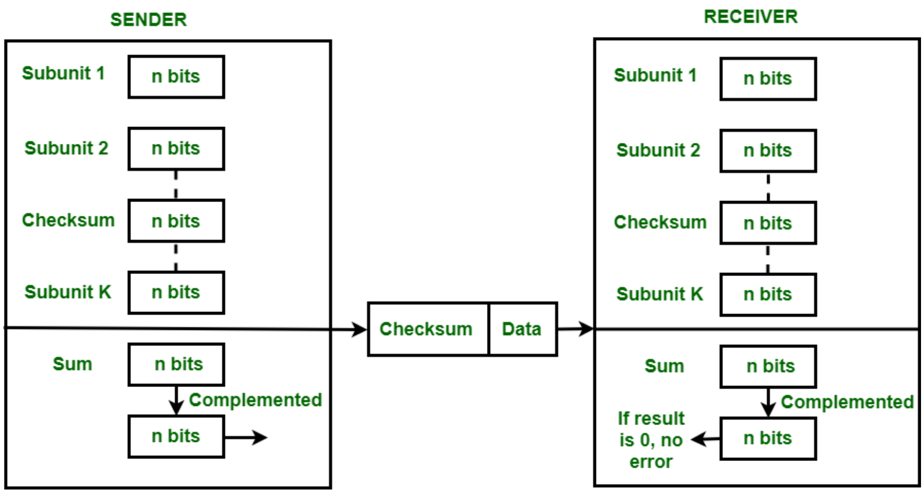
Advantages:

1. **Simple Implementation:** Checksum calculation and verification algorithms are relatively simple to implement, requiring minimal computational resources.
2. **Efficiency:** Checksums provide a lightweight mechanism for detecting errors without significant overhead.
3. **Error Detection:** Checksums are effective in detecting common transmission errors, such as single-bit errors or burst errors, enhancing the reliability of data transmission.

Disadvantages:

1. **Limited Error Detection Capability:** Checksums may not detect all types of errors, especially if multiple errors occur that cancel each other out or if the checksum length is insufficient.
2. **No Error Correction:** Checksums can only detect errors but cannot correct them. This limitation requires additional mechanisms, such as retransmission, to recover from errors.
3. **Vulnerability to Attacks:** Checksums alone are not secure against deliberate tampering or attacks, as an attacker could potentially modify both the data and the checksum to match.

Error Detection using Checksum



Example:

If the data unit to be transmitted is 10101001 00111001, the following procedure is used at Sender site and Receiver site.

Sender Side:

10101001 subunit 1

00111001 subunit 2

11100010 sum (using 1s complement)

00011101 checksum (complement of sum)

Receiver Side:

10101001 subunit 1

00111001 subunit 2

00011101 checksum

11111111 sum

00000000 sum's complement

Result is zero, it means no error.

CODE

```
#include <iostream>
#include <string>
using namespace std;
int C = 0, b_size;
string output;
char add(char a, char b) {
    if (C == 0 && (a == '1' && b == '1')) //0 1 1{
        C = 1;
        return '0';
    } else if (C == 0 && (a == '1' || b == '1')) //0 1 0  / 0 0 1{
        C = 0;
        return '1';
    } else if (C == 0 && (a == '0' && b == '0')) //0 0 0{
        C = 0;
        return '0';
    } else if (C == 1 && (a == '1' && b == '1')) //1 1 1{
        C = 1;
        return '1';
    } else if (C == 1 && (a == '1' || b == '1')) //1 0 1 / 1 1 0{
        C = 1;
        return '0';
    } else //1 0 0{
        C = 0;
        return '1';
    }}
void complement() {
    for (int k = b_size - 1; k >= 0; k--) {
        if (output[k] == '1')
            output[k] = '0';
```

```
        else
            output[k] = '1';
    }}
void compute_sum(string data) {
    string temp;
    output = data.substr(0, b_size);
    for (int i = b_size; i < data.length(); i += b_size) {
        int x = 0;
        temp = data.substr(i, b_size);
        for (int k = b_size - 1; k >= 0; k--)
            output[k] = add(output[k], temp[k]);
        if (C == 1) {
            for (int k = b_size - 1; k >= 0; k--) {
                if (C == 1) {
                    C = 0;
                    output[k] = add(output[k], '1');
                }}}  }
    complement();
}
int main() {
    int ch, i, found;
    string one,data;
    while (1) {
        cout << "\nChecksum\n1. Sender Side\n2. Receiver side\n3. Exit\nEnter choice: ";
        cin >> ch;
        switch (ch) {
        case 1:
            cout << "Enter data stream: ";
            cin >> data;
            cout << "Enter block size: ";
```

```
    cin >> b_size;
    compute_sum(data);
    cout << "The checksum is: " << output << "\n";
    // Append the checksum to the data
    data.append(output);
    cout << "The data with checksum is: " << data << "\n";
    break;
  case 2:
    cout << "Enter data stream: ";
    cin >> data;
    cout << "Enter block size: ";
    cin >> b_size;
    compute_sum(data);
    data = data.substr(0, data.length() - b_size);
    one = "1";
    found = output.find(one);
    if (found == string::npos) //0000
    {
      cout << "\nNo error present \nComplement of sum is  " << output;
      cout << "\nActual data is  " << data << "\n";
    } else //0010
    {
      cout << "Error present in code \n";
      cout << "\nComplement of sum is  " << output;
      cout << "\nSince complement is not equal to 0 error is present\n\n";
    }
    break;
  case 3:
    exit(0);
  default:
```

```
        cout << "Enter valid choice\n";
    }}}
```

OUTPUT

```
PS C:\Users\DIGGAJ\Desktop\Diggaj\Colleg

Checksum
1. Sender Side
2. Receiver side
3. Exit
Enter choice: 1
Enter data stream: 11011001
Enter block size: 4
The checksum is: 1000
The data with checksum is: 110110011000

Checksum
1. Sender Side
2. Receiver side
3. Exit
Enter choice: 2
Enter data stream: 110110011000
Enter block size: 4

No error present
Complement of sum is  0000
Actual data is  11011001
```

```
Checksum
1. Sender Side
2. Receiver side
3. Exit
Enter choice: 2
Enter data stream: 110111011000
Enter block size: 4
Error present in code

Complement of sum is  1011
Since complement is not equal to 0 error is present


Checksum
1. Sender Side
2. Receiver side
3. Exit
Enter choice: 3
```

ii) Error Detection using Cyclic Redundancy Check (CRC) in Computer Networks:

Introduction:

- Cyclic Redundancy Check (CRC) is a method used for error detection in data transmission.
- CRC involves appending a checksum, computed using polynomial division, to the data being transmitted.
- At the receiver's end, the checksum is recalculated, and if it matches the received checksum, the data is considered intact; otherwise, errors are detected.

Real-World Use Case:

- CRC is widely employed in network protocols such as Ethernet, Wi-Fi, and Bluetooth.
- In Ethernet, CRC is used in the Frame Check Sequence (FCS) to detect errors in the transmitted frames.
- Similarly, in Wi-Fi and Bluetooth, CRC is utilized to ensure the integrity of data packets transmitted wirelessly.

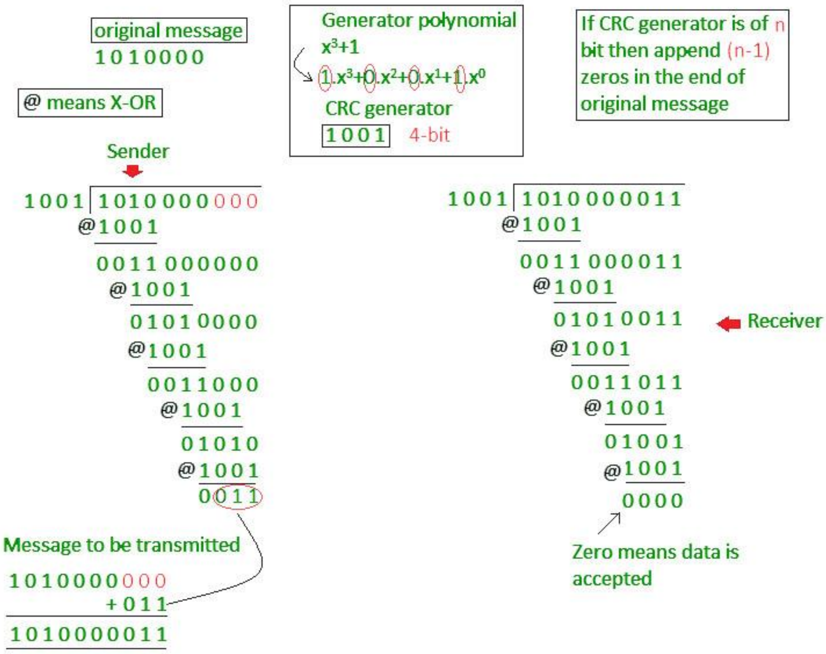
Advantages:

1. **High Accuracy:** CRC can detect a wide range of errors, including single-bit errors, burst errors, and most multiple-bit errors.
2. **Efficiency:** Despite its high error detection capability, CRC is computationally efficient, making it suitable for real-time data transmission.
3. **Error Localization:** CRC can not only detect errors but also provide some information about their location within the data packet, aiding in error correction strategies.

Disadvantages:

1. **Complexity:** Implementing CRC requires more computational resources and is more complex compared to simpler error detection techniques like checksums.
2. **False Positives:** Although rare, CRC can produce false positives, where the received data and checksum match even though errors are present, leading to undetected errors.
3. **Inability to Correct Errors:** Like checksums, CRC can only detect errors but cannot correct them, necessitating additional mechanisms for error recovery, such as retransmission.

Example:



CODE

```
#include<iostream>
using namespace std;
string xor1(string a, string b) {
  string result = "";
  int n = b.length();
  for (int i = 1; i < n; i++) {
    if (a[i] == b[i])
      result += "0";
    else
      result += "1";}
  return result;
}
string mod2div(string dividend, string divisor) {
  int pick = divisor.length();
```

```
  string tmp = dividend.substr(0, pick);
  int n = dividend.length();
  while (pick < n) {
    if (tmp[0] == '1')
      tmp = xor1(divisor, tmp) + dividend[pick];
    else
      tmp = xor1(std::string(pick, '0'), tmp) + dividend[pick];
    pick += 1;}
  if (tmp[0] == '1')
    tmp = xor1(divisor, tmp);
  else
    tmp = xor1(std::string(pick, '0'), tmp);
  return tmp;}
void encodeData(string data, string key) {
  int l_key = key.length();
  string appended_data = (data + std::string(l_key - 1, '0'));
  string remainder = mod2div(appended_data, key);
  string codeword = data + remainder;
  cout << "Remainder : " << remainder << "\n";
  cout << "Encoded Data (Data + Remainder) :" << codeword <<"\n";}
void receiver(string data, string key) {
  string currxor = mod2div(data.substr(0, key.size()), key);
  int curr = key.size();
  while (curr != data.size()) {
    if (currxor.size() != key.size()) {
      currxor.push_back(data[curr++]);
    } else {
      currxor = mod2div(currxor, key);
    }}
  if (currxor.size() == key.size()) {
```

```
    currxor = mod2div(currxor, key);
  }
  if (currxor.find('1') != string::npos) {
    cout << "There is some error in data" << endl;
  } else {
    cout << "Correct message received" << endl;
  }}
int main() {
  string data, key;
  cout << "Sender side" << endl;
  cout << "Enter the Data" << endl;
  cin >> data;
  cout << "Enter the Generator" << endl;
  cin >> key;
  encodeData(data, key);
  cout << "\nReceiver side" << endl;
  receiver(data + mod2div(data + std::string(key.size() - 1, '0'), key), key);
  return 0;
}
```

OUTPUT

```
PS C:\Users\DIGGAJ\Desktop\Diggaj\College\GEC\
Sender side
Enter the Data
1010110
Enter the Generator
1011
Remainder : 100
Encoded Data (Data + Remainder) :1010110100

Receiver side
Correct message received
```

CONCLUSION:

The Error Detection using Checksum and Cyclic Redundancy Check (CRC) was studied and implemented successfully.