Computer Network Lab

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Class: BCSE 3rd Year 1st Sem

Section: A3

Assignment No: 1

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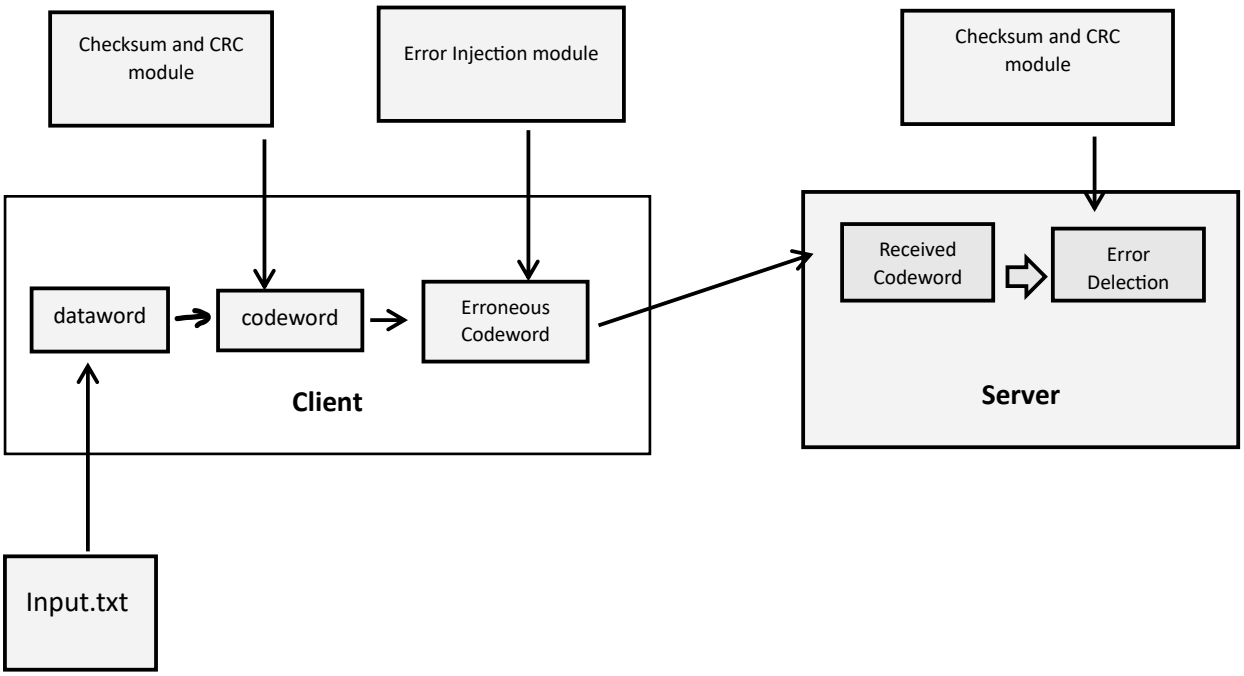
Problem Statement: Design and implement an error detection module which has two schemes namely Checksum and Cyclic Redundancy Check(CRC).

Design:

This program is designed to implement Checksum and Cyclic Redundancy Check(CRC) to detect error in data transmission. At server side we extract the data word from a given text file containing a sequence of 0 and 1 and create codeword using the Checksum and CRC scheme and send the codeword to the server. At server side, the server using Checksum and CRC scheme check whether there is an error or not.

To simulate a noise channel we create a error injection module which is called at the sender side to inject error in the codeword.



Schematic Diagram

Implementation:

CheckSum Scheme:

```
//return the checksum string of word_len length
module.exports.getChecksum= function getChecksum(wordList,word_len){
    let sum=0;
    let limit=(1<<word_len);
    for(i of wordList){
        sum+=parseInt(i,2);//convert a binary string into decimal
        if(sum>=limit){//convert to wrap sum
            sum=sum%limit+1;//convert a decimal into binary string
        }
    }
    sum=sum.toString(2);
    //make the length equal to word_len
    while(sum.length!=word_len){
        sum='0'+sum;
    }
    let checksum="";
    //1's complement to get the checksum
    for(let i=0;i<word_len;i++){
        if(sum.charAt(i)=="1"){
            checksum=checksum+"0";
        }
        else{
            checksum=checksum+"1";
        }
    }
    return checksum;
};


//return the codeword string
module.exports.getChecksumCodeWord= function
getChecksumCodeWord(dataword_raw,word_len){
    //make the length multiple of word_len(in our case 16)
    let dataword=dataword_raw;
    // console.log("data word length ",dataword.length);
    while(dataword.length%word_len!=0){
        dataword='0'+dataword;
    }
    let wordList=[];//will contain the 16 bit words of the dataword
    for(let i=0;i<(dataword.length/word_len);i++){
        wordList.push(dataword.substring(i*word_len,(i+1)*word_len));
    }

    let checksum=this.getChecksum(wordList,word_len);
    // console.log("binary check sum",checksum,"decimal
checksum",parseInt(checksum,2));
```

```
    let checksum_codeword=dataword_raw+checksum;
    return checksum_codeword;
};

//return boolean
module.exports.isValidChecksum=function
isValidChecksum(codeword_raw,word_len){
    let codeword=codeword_raw;
    // console.log("data word length ",codeword.length);
    while(codeword.length%word_len!=0){
        codeword='0'+codeword;
    }
    let wordList=[];//will contain the 16 bit words of the codeword
    for(let i=0;i<(codeword.length/word_len);i++){
        wordList.push(codeword.substring(i*word_len,(i+1)*word_len));
    }
    let checksum=this.getChecksum(wordList,word_len);
    // console.log("binary check sum",checksum,"decimal
checksum",parseInt(checksum,2));
    return parseInt(checksum,2)==0;
};
```

CRC Scheme:

```
// return the codeword string
module.exports.getCRCCodeWord= function(dataword_raw,generator){
    let dataword=dataword_raw;
    //creating augmented data word
    for(let i=0;i<generator.length-1;i++){
        dataword=dataword+"0";
    }
    //created augmented polynomial
    let polyarr=new Array(dataword.length);
    polyarr.fill(0);
    let l=dataword.length-1;
    for(let i=0;i<=l;i++){
        if(dataword.charAt(l-i)=="1"){
            polyarr[i]=1;
        }
    }
    let g=generator.length-1;// g is the degree of the polynomial as well as
the length of the remainder
    //creating generator polynomial
    let garr=new Array();
    for(let i=0;i<=g;i++){
        if(generator.charAt(g-i)=="1"){
            garr.push(i);
        }
```

```
    }
    //calculating the remainder
    for(let i=l;i>=g;i--){
        if(polyarr[i]==1){
            let x=i-g;
            for(let ele of garr){
                polyarr[ele+x]=polyarr[ele+x]^1;
            }
        }
    }
    //getting the binary string remainder
    let remainder="";
    for(let i=0;i<g;i++){
        if(polyarr[i]==1){
            remainder="1"+remainder;
        }
        else{
            remainder="0"+remainder;
        }
    }
    let codeword=dataword_raw+remainder;
    return codeword;
};


//return boolean
module.exports.isValidCRC= function(codeword_raw,generator){
    let dataword=codeword_raw;
    //creating polynomial of codeword
    let polyarr=new Array(dataword.length);
    polyarr.fill(0);
    let l=dataword.length-1;
    for(let i=0;i<=l;i++){
        if(dataword.charAt(l-i)=="1"){
            polyarr[i]=1;
        }
    }
    let g=generator.length-1;// g is the degree of the polynomial as well as
the length of the remainder
    //creating generator polynomial
    let garr=new Array();
    for(let i=0;i<=g;i++){
        if(generator.charAt(g-i)=="1"){
            garr.push(i);
        }
    }
    //calculating the remainder
    for(let i=l;i>=g;i--){
        if(polyarr[i]==1){
```

```
            let x=i-g;
            for(let ele of garr){
                polyarr[ele+x]=polyarr[ele+x]^1;
            }
        }
    }
    //getting the binary string remainder
    let remainder="";
    for(let i=0;i<g;i++){
        if(polyarr[i]==1){
            remainder="1"+remainder;
        }
        else{
            remainder="0"+remainder;
        }
    }
    // let codeword=dataword_raw+remainder;
    // return codeword;
    // console.log(remainder);
    return parseInt(remainder,2)==0;
};
```

Error Injection Module:

```
function randomIntFromInterval(min, max) { // min and max included
    return Math.floor(Math.random() * (max - min + 1) + min)
}

module.exports.injectSingleError=function(codeword_raw){
    let len=codeword_raw.length;
    let randomIndex=randomIntFromInterval(0,len-1);
    if(codeword_raw.charAt(randomIndex)=="1"){
        return codeword_raw.replaceAt(randomIndex,"0");
    }
    else{
        return codeword_raw.replaceAt(randomIndex,"1");
    }
};


module.exports.injectTwoIsolatedError=function(codeword_raw){
    let len=codeword_raw.length;
    let randomIndex=randomIntFromInterval(0,len-1);
    if(codeword_raw.charAt(randomIndex)=="1"){
        codeword_raw=codeword_raw.replaceAt(randomIndex,"0");
    }
    else{
```

```
        codeword_raw=codeword_raw.replaceAt(randomIndex,"1");
    }
    let ranInd=randomIntFromInterval(2,len-2);
    randomIndex=(randomIndex+ranInd)%len;
    if(codeword_raw.charAt(randomIndex)=="1"){
        codeword_raw=codeword_raw.replaceAt(randomIndex,"0");
    }
    else{
        codeword_raw=codeword_raw.replaceAt(randomIndex,"1");
    }
    return codeword_raw;
}

module.exports.injectOddError=function(codeword_raw){
    let len=codeword_raw.length;
    let no=randomIntFromInterval(0,len);
    if(no%2==0){
        no=(no+1)%len;
    }
    let mark=new Array(len);
    mark.fill(0);
    let count=0;

    while(count<no){
        let randomIndex=randomIntFromInterval(0,len-1);
        if(mark[randomIndex]==0){
            mark[randomIndex]=1;
            count++;
            if(codeword_raw.charAt(randomIndex)=="1"){
                codeword_raw=codeword_raw.replaceAt(randomIndex,"0");
            }
            else{
                codeword_raw=codeword_raw.replaceAt(randomIndex,"1");
            }
        }
    }
    return codeword_raw;
};

module.exports.injectBurstError=function(codeword_raw,error_len){
    if(error_len==0){
        return codeword_raw;
    }
    let len=codeword_raw.length;
    error_len=Math.min(len,error_len);
    let randomIndex=randomIntFromInterval(0,len-error_len);
    let newError="";
    for(let i=0;i<error_len;i++){
```

```
        if(codeword_raw.charAt(i+randomIndex)=="1"){
            codeword_raw=codeword_raw.replaceAt(i+randomIndex,"0");
        }
        else{
            codeword_raw=codeword_raw.replaceAt(i+randomIndex,"1");
        }
    }
    return codeword_raw;
};


module.exports.bypasscrc=function(codeword,generator){
    if(codeword.length>generator.length){
        return codeword;
    }
    let l=generator.length;
    for(let i=0;i<l;i++){
        let codeind=codeword.length-1-i;
        let generatorind=generator.length-1-i;
        if(generator.charAt(generatorind)=="1"){
            if(codeword.charAt(codeind)=="1"){
                codeword=codeword.replaceAt(codeind,"0");
            }
            else{
                codeword=codeword.replaceAt(codeind,"1");
            }
        }
    }
    return codeword;
}


module.exports.bypasschecksum=function(codeword_raw,word_len){
    let codeword=codeword_raw;
    // console.log("data word length ",dataword.length);
    while(codeword.length%word_len!=0){
        codeword='0'+codeword;
    }
    let wordList=[];//will contain the 16 bit words of the dataword
    for(let i=0;i<(codeword.length/word_len);i++){
        wordList.push(codeword.substring(i*word_len,(i+1)*word_len));
    }
    let l=wordList.length;
    // let flag=false;
    for(let i=0;i<word_len;i++){
        let one=0;
        let zero=0;
        for(let j=1;j<l;j++){
            if(wordList[j].charAt(i)=="1"){
```

```
                one++;
            }
            else{
                zero++;
            }
        }
        if(zero>0&&one>0){
            let oneind=0;
            for(let j=1;j<l;j++){
                if(wordList[j].charAt(i)=="1"){
                    oneind=j;
                    break;
                }
            }
            let zeroind=0;
            for(let j=1;j<l;j++){
                if(wordList[j].charAt(i)=="0"){
                    zeroind=j;
                    break;
                }
            }
            wordList[oneind]=wordList[oneind].replaceAt(i,"0");
            wordList[zeroind]=wordList[zeroind].replaceAt(i,"1");
            break;
        }
    }
    let newCodeword="";
    for(let str of wordList){
        newCodeword=newCodeword+str;
    }
    return newCodeword.substring(newCodeword.length-codeword_raw.length);
}
```

Test Cases and Results:

Below are some test cases for which the schemes are failed to detect error.

Codeword	**Received Codeword**	**Check sum**	**CRC 8**	**CRC 10**	**CRC 16**	**CRC 32**
10010010110011100000110010 10110101101001011000111111 011100100(For Checksum)	10010010110010100000110010 10110101101001011001111111 011100100(For Checksum)	Not detected	N/A	N/A	N/A	N/A
10010010110011100000110010 10110101101001011001001101 1 (For CRC-8)	10010010110011100000011001 01011010110100101100100110 11 (For CRC-8)	N/A	Not detected	N/A	N/A	N/A
10010010110011100000110010 10110101101001011000001011011 (For CRC-10)	10010010110011100000011001 01011010110100101100000101 1011 (For CRC-10)	N/A	N/A	Not detected	N/A	N/A
10010010110011100000011001010 11010110100101100100110111111011 10 (For CRC-16)	10010010110011100000110010 10110101101001011001001101111101110 (For CRC-16)	N/A	N/A	N/A	Not detected	N/A
10010010110011100000110010101101 01011010010110001000011011001100 0111111110010111 (For CRC-32)	10010010110011100000110010 10101101011010010110001000011011001 100111111110010111 (For CRC-32)	N/A	N/A	N/A	N/A	Not detected

Analysis:

From the above test cases we can see that all the scheme has some limitation.

For the checksum scheme if equal number of 1s and 0s get flipped at the same bit position during transmission then the checksum remains same but it introduced error in the codeword. Since the chechsum remains same the error is not detected at the server side.

For the CRC scheme if the error is divisible by the dividend(generator polynomial) then the error is not detected at the server side.

Comments:

Through this assignment I have learnt the Checksum and Cyclic Redundancy Check(CRC) scheme for error detection in data communication and there importance in data transmission and also how it is implemented in physical layer. Also I come to know that when this schemes get failed to detect error.

Implementing the error generating algorithm that will not be detected by the schemes were a tricky part and gives me a deep understanding of the schemes.