3D3 Data Link Protocol Simulation
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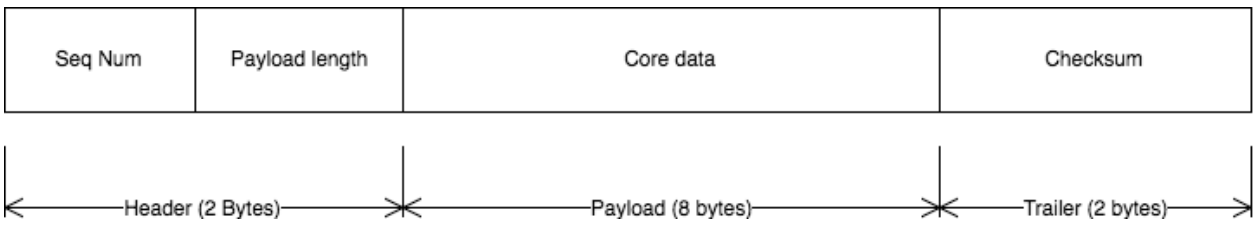
Description

The purpose of this project was to simulate the transfer of raw data (alphanumeric characters) from a client to a server. The data is transferred in a binary string.
Along with the 8 input characters (1 byte per char) there is a header consisting of 2 bytes containing the sequence number and payload length. The trailer contains 2 bytes to store the checksum for the input data calculated using the CRC16 algorithm that will ensure data integrity.

The server/client can hold 5 frames in its buffer. The server verifies the data is not corrupt by calculating the checksum. It then sends an acknowledgement (ACK with frame number) back along with the frame number and both the server and client remove that frame from the buffer.

If the packet is corrupt the server sends a negative acknowledgement (NAK with frame number) and the client resends the frame and waits for an ACK. This is known as selective repeat mode. The server can now write the data to the output file. It does this until all of the frames have been received.



Code

Transmitter

```
#include <stdio.h>
#include <stdlib.h>
#include <stdint.h>
#include <string>
```

```
#include <bitset>
#include <iostream>

#include <sys/types.h>
#include <sys/socket.h>
#include <netinet/in.h>
#include <netdb.h>
#include <arpa/inet.h>
#include <unistd.h>

#define POLY 0x8408

const int INPUT = 1024;
const int PAYLOADLENGTH = 8; //number of bytes per payload
const int MAXPACKETS = INPUT/PAYLOADLENGTH;

using namespace std;

struct dataFrame{

    bitset <8*2> header; //sequence number, Payload Length
    bitset <PAYLOADLENGTH*8> coredata;
    bitset <16> trailer; //checksum
    dataFrame* next;
    int seq;
};


unsigned short crc16(char *data_p, unsigned short length){
    unsigned char i;
    unsigned int data;
    unsigned int crc = 0xffff;

    if (length == 0)
        return (~crc);

    do
    {
        for (i=0, data=(unsigned int)0xff & *data_p++;
             i < 8;
             i++, data >>= 1)
        {
            if ((crc & 0x0001) ^ (data & 0x0001))
                crc = (crc >> 1) ^ POLY;
            else  crc >>= 1;
        }
    } while (--length);

    crc = ~crc;
    data = crc;
    crc = (crc << 8) | (data >> 8 & 0xff);

    return (crc);
}
```

```
char gremlin(char data){
    int num = 0;
    num = rand()%20;

    if (num == 5){
        data = ' ';
    }
    return data;
}


int main(){
    char data[INPUT], buffer[256], tempchararray[3],
temp[PAYLOADLENGTH];
    FILE *fp;
    int clientSocket, portNum, n, QUE = 0, sentSuccesfully =0,
i=0;
    string tempChar, core, checksum, headerT;;
    unsigned short crc;
    dataFrame* head = NULL;
    dataFrame* tempFrame = NULL;

    struct sockaddr_in serverAddr;
    struct hostent *serverName;

    portNum = 12000;

    //reading in data to be transmitted
    fp = fopen("ASCIIdata.txt", "r");

    for (int i = 0; i<1024; i++){
        data[i] = fgetc(fp);
    }

    //connecting to socket
    clientSocket = socket(AF_INET, SOCK_STREAM, 0);
    if (clientSocket < 0)
    {
        printf("Error: Unable to open the socket");
        return -1;
    }

    serverName = gethostbyname("localhost"); // host name

    bzero((char *) &serverAddr, sizeof(serverAddr));
    serverAddr.sin_family = AF_INET;

    bcopy(
          (char *)serverName->h_addr,
           (char *)&serverAddr.sin_addr.s_addr,
           serverName->h_length
          );
```

```
    //conecting to reciever
    serverAddr.sin_port = htons(portNum);
    serverAddr.sin_addr.s_addr = INADDR_ANY;


    if (connect(clientSocket,(struct sockaddr *)
&serverAddr,sizeof(serverAddr)) < 0)
    {
        printf("ERROR connecting");
        return -1;
    }


    // prepare data to send

    while(sentSuccesfully < MAXPACKETS){

        //fill the buffer
        while(QUE < 5){
            //split data into frame to be sent
            for(int j=0; j < PAYLOADLENGTH; j++){
                temp [j] = data[(PAYLOADLENGTH*i)+ j];
                bitset<8> coreFrame(temp[j]);
                core += coreFrame.to_string();
            }
            string tempstr = temp;

            //Calculate CRC16
            crc = (crc16(temp, 8));
            bitset<16> tempTrailer(crc);
            checksum = to_string(crc);


            //Prepare data to be sent
            bitset <8*PAYLOADLENGTH> tempCore(core);
            bitset<8> tempHeader1(i+1);
            bitset<8> tempHeader2(64);
            headerT = tempHeader1.to_string() +
tempHeader2.to_string();
            bitset<16> tempHeader(headerT);

            //store in buffer until ACK recieved
            if(QUE == 0){
                head = new dataFrame;
                head->coredata = tempCore;
                head->header = tempHeader;
                head->trailer = tempTrailer;
                head->seq = i+1;
                head->next = NULL;
                QUE++;
            }
            else{
                dataFrame* temp = head;
                //go to end of list
```

```
                while (temp->next) {
                    temp = temp->next;
                }
                temp->next = new dataFrame;
                temp = temp->next;
                temp->coredata = tempCore;
                temp->header = tempHeader;
                temp->trailer = tempTrailer;
                temp->seq = i+1;
                temp->next = NULL;
                QUE++;
            }

            core = "";
            checksum= "";
            crc = 0;

            //apply gremlin function on random bit
            tempCore[18] = gremlin(tempCore[18]);

            //send the data to the reciever
            printf("Sending Frame: %i \n", i+1);

            string buff = headerT + tempCore.to_string() +
tempTrailer.to_string();
            bzero(buffer,256);
            strcpy(buffer, buff.c_str());
            n = sendto(clientSocket, &buffer, sizeof(buffer),
0,(struct sockaddr*) &serverAddr, sizeof(serverAddr));
            if (n < 0)
            {
                printf("ERROR writing to socket\n");
                return -1;
            }

            i++;
            cout << "\n\n";
        }

        //When the reciever sends an ACK back for a particular
frame
        //remove it from the buffer or send back frame if NAK
recieved
        printf("waiting for ACK/NAK\n");
        bzero(buffer,256);
        n =
recvfrom(clientSocket,&buffer,sizeof(buffer),0,(struct
sockaddr*) &serverAddr, (socklen_t *)&serverAddr);
        if (n < 0)
        {
            printf("ERROR reading from socket\n");
            return -1;
        }
```

```
        //Parse the reply
        string recieved(buffer);
        string reply ="";
        bitset<24> replyBits(recieved.substr(0,24));
        bitset<8> frameNumBit(recieved.substr(24,8));
        int frameNum = (int)frameNumBit.to_ulong();
        reply = replyBits.to_string();

        for(int i=0; i <3; i++){
            tempChar = reply.substr(i*8,8);
            bitset<8> replyChar(tempChar);
            tempchararray[i] = char(replyChar.to_ulong());
        }

        reply = tempchararray;

        //remove frame acknowleged from the buffer
        if(reply == "ACK"){
            if(head->seq == frameNum){
                printf("frame %i has been ACKed \n",
frameNum);
                QUE--;
                sentSuccesfully++;
                //delete node from linked list
                dataFrame* p = head;
                head = head->next;
                delete p;
            }
            else{
                //check rest of linked list for frame
                tempFrame = head;
                dataFrame* t = NULL;
                while(tempFrame->seq != frameNum){
                    t = tempFrame;
                    tempFrame = tempFrame->next;

                }
                if(tempFrame->seq == frameNum){
                    printf("frame %i has been ACKed \n",
frameNum);
                    QUE--;
                    sentSuccesfully++;
                    //delete node
                    dataFrame* tp = tempFrame;
                    t->next = tempFrame->next;
                    delete tp;
                }
                else{
                    printf("ERROR: Frame %i Not found in
list\n", frameNum);
                }
            }
        }
        //resend frame that was corrupted
```

```
        else{
            printf("Frame %i has been NAKed\n", frameNum);
            if(head->seq == frameNum){
                string buff = head->header.to_string() + head-
>coredata.to_string() + head->trailer.to_string();
                bzero(buffer,256);
                strcpy(buffer, buff.c_str());
                printf("Resending frame\n");
                n = sendto(clientSocket, &buffer,
sizeof(buffer), 0,(struct sockaddr*) &serverAddr,
sizeof(serverAddr));
                if (n < 0)
                {
                    printf("ERROR writing to socket\n");
                    return -1;
                }
            }
            else{
                tempFrame = head;
                while(tempFrame->seq != frameNum){
                    tempFrame = tempFrame->next;
                }
                if(tempFrame->seq != frameNum){
                    printf("error not in resend list\n");
                }
                else{
                    string buff = tempFrame-
>header.to_string() + tempFrame->coredata.to_string() +
tempFrame->trailer.to_string();
                    bzero(buffer,256);
                    strcpy(buffer, buff.c_str());
                    printf("Resending frame\n");
                    n = sendto(clientSocket, &buffer,
sizeof(buffer), 0,(struct sockaddr*) &serverAddr,
sizeof(serverAddr));
                    if (n < 0)
                    {
                        printf("ERROR writing to socket\n");
                        return -1;
                    }
                }
            }
        }
        reply = "";


    }

    printf("All frames have been acknowledged\n\n");
    close(clientSocket);



    return 0;
```

```
}
```

Receiver

```
//
//  reciever.cpp
//
//
//  Created by Hugh Lavery on 19/02/2017.
//
//

#include <stdio.h>
#include <stdlib.h>
#include <stdint.h>
#include <string>
#include <bitset>
#include <iostream>

#include <sys/types.h>
#include <sys/socket.h>
#include <netinet/in.h>
#include <netdb.h>
#include <arpa/inet.h>
#include <unistd.h>

#define POLY 0x8408

const int PAYLOADLENGTH = 8;

using namespace std;

struct dataFrame{
    int seq;
    string data;
    bitset <8*2> header; //sequence number, Payload Length
    bitset <PAYLOADLENGTH*8> coredata;
    bitset <16> trailer; //checksum
    dataFrame* next;
    int sourceCRC;
};
```

```
unsigned short crc16(char *data_p, unsigned short length){
    unsigned char i;
    unsigned int data;
    unsigned int crc = 0xffff;

    if (length == 0)
        return (~crc);

    do
    {
        for (i=0, data=(unsigned int)0xff & *data_p++;
             i < 8;
             i++, data >>= 1)
        {
            if ((crc & 0x0001) ^ (data & 0x0001))
                crc = (crc >> 1) ^ POLY;
            else  crc >>= 1;
        }
    } while (--length);

    crc = ~crc;
    data = crc;
    crc = (crc << 8) | (data >> 8 & 0xff);

    return (crc);
}

void writeToFile(char* characters){

    FILE *fp;
    fp = fopen("output.txt", "a+");
    char t;

    for(int i =0; i <PAYLOADLENGTH; i++){
        t = characters[i];
        fputc(t,fp);
    }

}

char gremlin(char data){
    int num = 0;
    num = rand()%20;

    if (num < 5){
        data = ' ';
    }
    return data;
}

int main(){
    int serverSocket, portNum, clientAddrLen, n, count =1,
seqNumint =0, lengthNumint=0, QUE =0, crcNumint, checksumint;
```

```
    char buffer[256], tempcharArray[PAYLOADLENGTH], ack[3],
nak[3];
    struct sockaddr_in serverAddr, clientAddr;
    string headerStr, seqNumStr, lengthNumStr, ACK, NAK, data,
coredata, crcStr, coretempStr, characterTemp, checksum, reply;
    portNum = 12000;
    dataFrame *head = NULL;
    unsigned short crc;
    dataFrame *pTemp;

    FILE *fp;
    fp = fopen("output.txt", "w");

    ack[0] = 'A';
    ack[1] = 'C';
    ack[2] = 'K';

    nak[0] = 'N';
    nak[1] = 'A';
    nak[2] = 'K';

    //Preparing ACK and NAK replies
    for (int i=0; i<3;i++){
        bitset<8> ackBits(ack[i]);
        ACK += ackBits.to_string();
        bitset<8> nakBits(nak[i]);
        NAK += nakBits.to_string();
    }

    //Opening socket
    serverSocket = socket(AF_INET, SOCK_STREAM, 0);
    if (serverSocket < 0){
        printf("Error: Could not open socket");
        return -1;
    }
    //Getting transmitter data
    bzero((char*) &serverAddr, sizeof(serverAddr));
    serverAddr.sin_family = AF_INET;
    serverAddr.sin_port = htons(portNum);
    serverAddr.sin_addr.s_addr = INADDR_ANY;

    if(bind(serverSocket, (struct sockaddr*) &serverAddr,
sizeof(serverAddr)) < 0)
    {
        printf("Error: Socket is in use\n");
        return -1;
    }
    listen(serverSocket, 5);

    clientAddrLen = sizeof(clientAddr);
    //accepting incoming connect
    serverSocket = accept(serverSocket, (struct sockaddr*)
&clientAddr, (socklen_t *)&clientAddr);
```

```
    count =1;
    while(count < 129){
        //Fill buffer
        while(QUE < 5){
            usleep(100);
            bzero(buffer, 256);
            printf("Waiting to recieve frame %i\n", count);
            //Recieving frame
            n = recvfrom(serverSocket, &buffer,
sizeof(buffer), 0, (struct sockaddr*) &clientAddr, (socklen_t
*)&clientAddr);
            if(n < 0)
            {
                printf("Error: Could not read from socket");
                return -1;
            }
            //Parsing Frame number from incoming header
            data = buffer;
            seqNumStr = data.substr(0,8);
            bitset<8> seqNum(seqNumStr);
            seqNumint =(int)(seqNum.to_ulong());

            //Parsing length of input data
            lengthNumStr = data.substr(8,8);
            bitset<8> lengthNum(lengthNumStr);
            lengthNumint = (int)(lengthNum.to_ulong());

            //data extraction
            coredata = data.substr(16,(lengthNumint));
            bitset<64> coreBits(coredata);

            //gremlin on data recieved
            coreBits[30] = gremlin(coreBits[30]);

            //crc extraction
            crcStr = data.substr((16+lengthNumint), 16);
            bitset<16> crcNum(crcStr);
            crcNumint = (int)crcNum.to_ulong();

            //store in buffer
            if (QUE == 0){
                head = new dataFrame;
                head->data = data;
                bitset<8> tempSeq(seqNum);
                bitset<8> tempLength(lengthNum);
                string headerT = tempSeq.to_string() +
tempLength.to_string();
                bitset<16> headerBits(headerT);
                head->header = headerBits;
                head->coredata = coreBits;
                head->trailer = crcNumint;
                head->seq = seqNumint;
                head->next = NULL;
                head->sourceCRC = crcNumint;
```

```
                QUE++;
            }

            else if(QUE <= 5){
                dataFrame* temp = head;
                //go to end of list
                while (temp->next) {
                    temp = temp->next;
                }
                temp->next = new dataFrame;
                temp = temp->next;
                temp->data = data;
                bitset<8> tempSeq(seqNum);
                bitset<8> tempLength(lengthNum);
                string headerT = tempSeq.to_string() +
tempLength.to_string();
                bitset<16> headerBits(headerT);
                temp->header = headerBits;
                temp->coredata = coreBits;
                temp->trailer = crcNum;
                temp->seq = seqNumint;
                temp->next = NULL;
                temp->sourceCRC = crcNumint;
                QUE++;
            }
        }

        //Find next Frame in sequence and ensure data
integrity
        //before writing to output file (cheking head of
linked list first)

        if(head->seq == count){
            coretempStr = head->coredata.to_string();
            for (int j =0; j<PAYLOADLENGTH; j++){
                characterTemp =
coretempStr.substr(PAYLOADLENGTH*j, 8);
                bitset <8> tempchar(characterTemp);
                tempcharArray[j] = char(tempchar.to_ulong());
            }
            //Calculating CRC16 on core data and checking
against
            //transmitters CRC16 value stored in the trailer
            coretempStr = tempcharArray;
            crc = (crc16(tempcharArray, 8));
            bitset <16> sourceCRCBits(crc);
            checksum = to_string(crc);
            checksumint = (int)sourceCRCBits.to_ulong();
           //if CRCs are the same send back ACK with Frame
number
            if (checksumint == head->sourceCRC){
                printf("Success crcs are the same for frame %i
\nSending ACK\n", count);
                bzero(buffer, 256);
```

```
                reply = "";

                bitset<8> countBits(count);
                reply = ACK + countBits.to_string();
                strcpy(buffer, reply.c_str());
                n = sendto(serverSocket, &buffer,
sizeof(buffer), 0, (struct sockaddr*) &clientAddr,
sizeof(clientAddr));

                if(n < 0)
                {
                    printf("Error: Could not write to
socket");
                }
                //delete node from list
                dataFrame *p = head;
                head = head->next;
                delete p;
                QUE--;
                printf("writing to file\n\n");
                //Write data out to file
                writeToFile(tempcharArray);
                count++;
            }
            else{//crc's are not same so data is corrupted
                printf("Data has been corrupted. Sending
NAK\n");
                bzero(buffer, 256);
                bitset<8> countBits(count);
                reply = NAK + countBits.to_string();
                strcpy(buffer, reply.c_str());
                n = sendto(serverSocket, &buffer,
sizeof(buffer), 0, (struct sockaddr*) &clientAddr,
sizeof(clientAddr));
                if(n < 0)
                {
                    printf("Error: Could not write to
socket");
                }
                //delete node from list
                dataFrame *p = head;
                head = head->next;
                delete p;
                QUE--;
            }

        }
        else{// Check rest of list
            dataFrame* temp = head;
            //go to end of list
            while (temp->next && temp->seq != count) {
                pTemp = temp;
                temp = temp->next;
            }
```

```
            if(temp->seq == count){
                coretempStr = temp->coredata.to_string();
                for (int j =0; j<PAYLOADLENGTH; j++){
                    characterTemp =
coretempStr.substr(PAYLOADLENGTH*j, 8);
                    bitset <8> tempchar(characterTemp);
                    tempcharArray[j] =
char(tempchar.to_ulong());
                }
                coretempStr = tempcharArray;
                crc = (crc16(tempcharArray, 8));
                bitset <16> sourceCRCBits(crc);
                checksum = to_string(crc);
                checksumint = (int)sourceCRCBits.to_ulong();

                if (checksumint == temp->sourceCRC){
                    printf("Success crcs are the same for
frame %i \nSending ACK\n", count);
                    //send back ack and correctly delete node
from list
                    bzero(buffer, 256);
                    bitset<8> countBits(count);
                    reply = ACK + countBits.to_string();
                    strcpy(buffer, reply.c_str());
                    n = sendto(serverSocket, &buffer,
sizeof(buffer), 0, (struct sockaddr*) &clientAddr,
sizeof(clientAddr));
                    if(n < 0)
                    {
                        printf("Error: Could not write to
socket");
                    }
                    //delete node from list
                    dataFrame *p = temp;
                    pTemp->next = temp->next;
                    delete p;
                    QUE--;
                    //Write out to file
                    printf("Writing to file\n\n");
                    writeToFile(tempcharArray);
                    count++;
                }
                else{//CRCs are not same so data is corrupted
send NAK
                    printf("Data has been corrupted. Sending

NAK\n");
                    bzero(buffer, 256);
                    bitset<8> countBits(count);
                    reply = NAK + countBits.to_string();
                    strcpy(buffer, reply.c_str());
                    n = sendto(serverSocket, &buffer,
sizeof(buffer), 0, (struct sockaddr*) &clientAddr,
sizeof(clientAddr));
                    if(n < 0)
```

```
                    {
                        printf("Error: Could not write to
socket");
                    }
                    //delete node from list
                    dataFrame *p = temp;
                    pTemp->next = temp->next;
                    delete p;
                    QUE--;
                }
            }

        }

    }

    printf("Frames all recived and printed out in order\n\n");

    return 0;

}
```