# UCS 1511 - Network Lab

## Exercise 7 - Hamming Code Error Detection and Correction

| | |
|---|---|
| **Name:** | Mahesh Bharadwaj K |
| **Reg No:** | 185001089 |
| **Semester:** | V |
| **Date:** | October 13, 2020 |

---

## Aim:

To implement hamming code error detection and correction using C socket program.

## Algorithm

### 1. Server (Sender)

```
1. Create a socket descriptor with socket() system call with AF_INET (IPV4 domain), SOCK_STREAM,
   default protocol and store as sockfd.
2. If sockfd is a negative number, socket creation failed, end program.
3. Create sockaddr_in object to assign IP address and Port number for socket. Set family to AF_INET,
   IP address to INADDR_ANY to accept connections from any client and port number required.
4. Bind newly created socket to addresss given in sockaddr_in.
5. If bind is non zero, bind failed, print error message and terminate.
6. Listen on the socked defined for as many clients as required. If listen() returns non zero value,
   print error message and terminate.
7. Read data to send from user into buffer, let len of buffer be 'n' bits.
8. Find number of redundant bits 'r' such that $2^r > n + r + 1$
9. Create a new buffer of size 'n + r' bits.
10. LOOP i: 1 → (n+r)
    • IF i is a power of 2, continue
    • Else buffer[i] = data[i]
11. LOOP i: 0 → r
    • pos = $2^i$
    • count = 0
    • LOOP j: 1 → (n+r)
        – IF j == pos, continue
        – ELSE IF binary(pos) in binary(j), count += buffer[j]
    • arr[pos] = 1 if count is odd, else 0
12. Introduce error at random bit of data buffer.
13. Accept connections of client into new_fd using accept() system call.
14. Send data buffer to client using send() system call.
15. Close connections on socket using close() and terminate program.
```

**2. Client (Receiver)**

1. Create a socket descriptor with **socket()** system call with AF_INET (IPV4 domain), SOCK_STREAM, default protocol and store as sockfd.
2. If sockfd is a negative number, socket creation failed, end program.
3. Create sockaddr_in object to assign IP address and Port number for socket. Set family to AF_INET, IP address to localhost(127.0.0.1) to connect to server and port number required.
4. Connect the client to server at address given in socket descriptor using **connect()** system call.
5. If connect() returns -1, connection failed; Print error message and terminate the program.
6. Read data sent by server into buffer using **read()** system call.
7. Find the length ‘n’ of buffer.
8. Number of redundant bits $r = \log_2 n$
9. Initialise arr of length ‘r’ with 0.
10. LOOP i: 0 → r
    - pos = $2^i$
    - count = 0
    - LOOP j: 1 → (n+r)
        - IF binary(pos) in binary(j), count += buffer[j]
    - arr[i] = 1 if count is odd, else 0
11. Convert arr to decimal
12. IF it is non zero, the decimal value represents the location of error and toggle bit at the location in the received buffer
13. ELSE IF it is zero, no error occurred during transmission or multiple bits were incorrect.
14. Print the buffer to user.
15. Close the connections on socket using **close()** and terminate program.

---

## Program

### 1. Server Side

```
#include <stdio.h>
#include <stdlib.h>
#include <time.h>
#include <sys/types.h>
#include <sys/socket.h>
#include <netinet/in.h>
#include <stdlib.h>
#include <string.h>
#include <unistd.h>
#include <arpa/inet.h>
#include <fcntl.h>
#include <stdbool.h>
#include <math.h>
#define MAXLINE 1024

#include  "Hamming.h"

int main(int argc, char ** argv)
{
```

```c
srand(time(NULL));

if (argc < 2){
    fprintf(stderr, "Enter port number as argument!\n");
    exit(EXIT_FAILURE);
}

int PORT = atoi(argv[1]);

int sockfd, newfd, n, arr[30], count = 0, bin;
char buff[MAXLINE], buffer[MAXLINE], data_t[40];
int i, j, r, total, nob, rem, dig, pos;
long data;
struct sockaddr_in servaddr,cliaddr;

if((sockfd = socket(AF_INET, SOCK_STREAM, 0)) < 0)
{
    perror("Socket creation failed!");
    exit(1);
}

bzero(&servaddr,sizeof(servaddr));
servaddr.sin_family = AF_INET; // IPv4
servaddr.sin_addr.s_addr = INADDR_ANY;
servaddr.sin_port = htons(PORT);

if(bind(sockfd, (const struct sockaddr *)&servaddr,sizeof(servaddr)) < 0)
{
    perror("Bind failed!");
    exit(1);
}

int len, m;
listen(sockfd, 2);
printf("Enter the data to send: ");
scanf("%lu", &data);

n = countbits(data);
r = log2(n);
r = floor(r);

// Finding number of redundant bits
while(pow(2, r) < n + r + 1)
    r += 1;


printf("\nNo.of redundant bits required: %d\n", r);
total = n + r;
nob = floor(log2(total));
for(i = 1; i <= total; i++)
{
    dig = data % 10;
    if(isapower2(i) == 0)
    {
        arr[total - i] = dig;
        data /= 10;
    }
    else
        arr[total-i]=0;
}
for(i = 0; i < r; i++)
```

```
    {
        for(j = 1; j <= total; j++)
        {
            if((int)(pow(2, i)) != j)
            {
                bin = binary(j);
                if(ispresent(bin, i + 1))
                    count += arr[total - j];
            }
        }
        if(count % 2 == 0)
            arr[total - (int)(pow(2, i))] = 0;
        else
            arr[total - (int)(pow(2, i))] = 1;
        count = 0;
    }
    printf("\nData with redundant bits: ");
    for(i = 0; i < total; i++)
        printf("%d", arr[i]);
    // printf("\nEnter error position: ");
    // scanf("%d", &pos);

    pos = rand() % total + 1;
    printf("\nIntroducing error automatically at bit: %d\n", pos);

    if(arr[total - pos] == 0)
        arr[total - pos] = 1;
    else
        arr[total - pos] = 0;

    int k = 0;
    long num = 0;
    for(i = total - 1; i >= 0; i--)
    {
        num += pow(10, k) * arr[i];
        k++;
    }
    sprintf(data_t, "%lu", num);
    printf("Data transmitted is %s\n", data_t);

    len = sizeof(cliaddr);
    newfd = accept(sockfd, (struct sockaddr*)&cliaddr, &len);
    m = write(newfd, data_t, sizeof(data_t));
}
```

---

**2. Client Side**

```
#include<stdio.h>
#include<sys/types.h>
#include<sys/socket.h>
#include<netinet/in.h>
#include<string.h>
#include<unistd.h>
#include<arpa/inet.h>
#include<stdlib.h>
#include<math.h>
#define MAXLINE 1024

#include "Hamming.h"
```

```c
int main(int argc, char **argv)
{
    if (argc < 2){
        fprintf(stderr, "Please enter port number as second argument!\n");
        exit(EXIT_FAILURE);
    }

    int PORT = atoi(argv[1]);

    long num;
    int sockfd, total, i, rem, arr[20], count = 0, r = 0, result = 0, bin, j,
    ↪   newarr[20], finalarr[20];
    char buffer1[40];
    struct sockaddr_in servaddr;
    if ((sockfd = socket(AF_INET, SOCK_STREAM, 0)) < 0) {
        perror("Socket creation failed!");
        exit(1);
    }
    bzero(&servaddr,sizeof(servaddr));
    servaddr.sin_family = AF_INET;
    servaddr.sin_port = htons(PORT);
    servaddr.sin_addr.s_addr = inet_addr("127.0.0.1");
    int n, len;
    connect(sockfd, (struct sockaddr*)&servaddr, sizeof(servaddr));
    n = read(sockfd, buffer1, sizeof(buffer1));
    num = atol(buffer1);
    total = countbits(num);
    printf("Received data: %lu\n", num);
    i = 1;
    while(num > 0)
    {
        rem = num % 10;
        arr[total - i] = rem;
        num /= 10;
        i++;
    }
    for(i = 1; i <= total; i++)
        if(ceil(log2(i)) == floor(log2(i)))
            r++;
    int k = 0;
    for(i = 0; i < 4; i++)
    {
        for(j = 1; j <= total; j++)
        {
            bin = binary(j);
            if(ispresent(bin, i + 1))
                count += arr[total - j];
        }
        if(count % 2 == 0)
            result += pow(10, k) * 0;
        else
            result += pow(10, k) * 1;
        k++;
        count=0;
    }
    int error = decimal(result);
    printf("\nError bit in binary: %d\n", result);
    printf("\nError in bit %d\n", error);
    if(arr[total - error] == 0)
        arr[total - error] = 1;
    else
        arr[total - error] = 0;
    k = 0;
    printf("\nData after error correction: ");
    for(i = total - 1; i >= 0; i--)
    {
        newarr[k] = arr[i];
        k++;
    }
    int x = 0;
    for(i = 0;i < k; i++)
    {
        if(ceil(log2(i + 1)) != floor(log2(i + 1)))
        {
            finalarr[x] = newarr[i];
            x++;
        }
    }
    for(i = x - 1; i >= 0; i--)
        printf("%d", finalarr[i]);
    printf("\n");
    return 0;
}
```

---

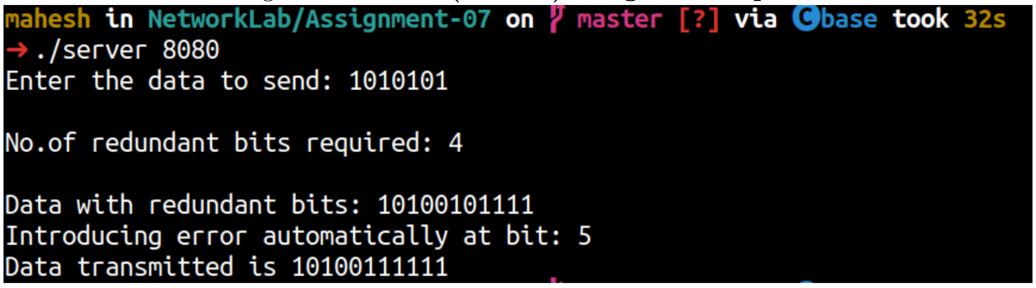
### 3. Hamming Code specific funtions

```
int countbits(long num)
{
    int r, count = 0;
    while(num > 0)
    {
        num = num / 10;
        count++;
    }
    return count;
}
int binary(int num)
{
    int bin = 0, r;
    int i = 0;
    while(num > 0)
    {
        r = num % 2;
        bin += r * pow(10, i);
        num /= 2;
        i++;
    }
    return bin;
}
int ispresent(int num,int pos)
{
    int rem;
    for(int i = 0; i < pos; i++)
    {
        rem = num % 10;
        num = num / 10;
    }
    if(rem == 1)
        return 1;
    else
        return 0;
}
int isapower2(int n)
{
    if(ceil(log2(n)) == floor(log2(n)))
        return 1;
    else
        return 0;
}

int decimal(int num)
{
    int rem, i = 0, result;
    while(num > 0)
    {
        rem = num % 10;
        result += pow(2, i) * rem;
        num /= 10;
        i++;
    }
    return result;
}
```

## Output

Figure 1: **Server (Sender) Program Output**

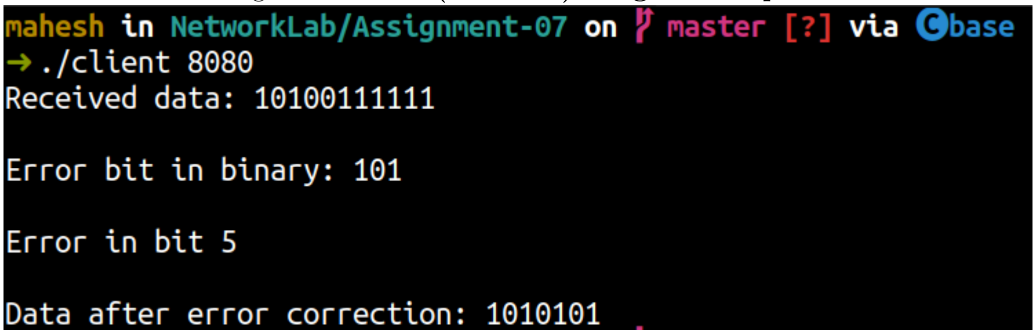


```
mahesh in NetworkLab/Assignment-07 on master [?] via base took 32s
➜ ./server 8080
Enter the data to send: 1010101

No.of redundant bits required: 4

Data with redundant bits: 10100101111
Introducing error automatically at bit: 5
Data transmitted is 10100111111
```

Figure 2: **Client (Receiver) Program Output**



```
mahesh in NetworkLab/Assignment-07 on master [?] via base
➜ ./client 8080
Received data: 10100111111

Error bit in binary: 101

Error in bit 5

Data after error correction: 1010101
```

## Learning Outcomes:

- We learn how to create a simple TCP client server connection.
- We learn how to appropriate system calls to set up Server and Client Programs.
- We learn the structure of ARP packet.
- We handle ARP request and send appropriate response to simulate ARP.