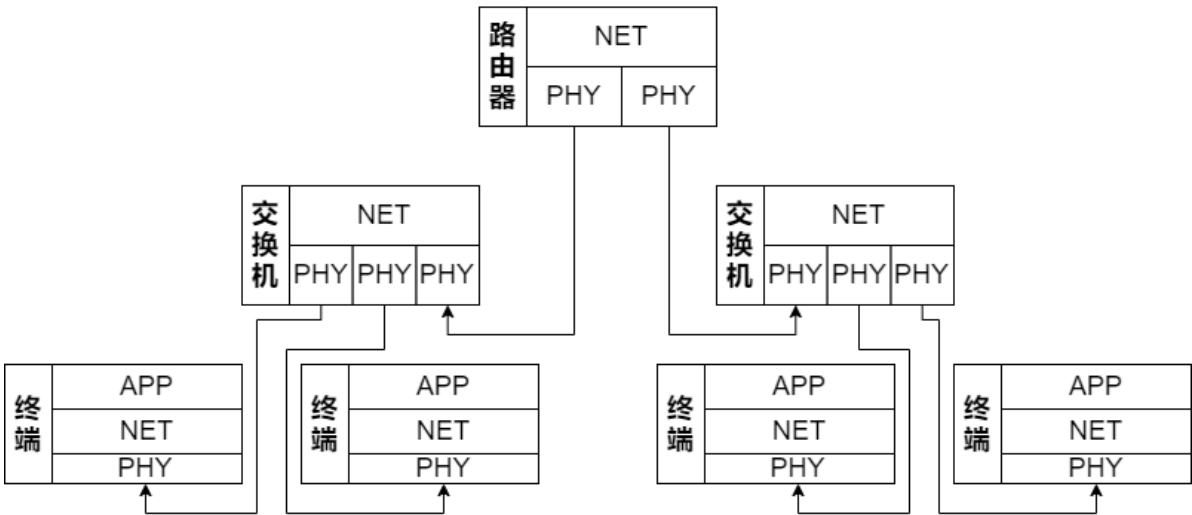


项目一阶段一报告

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整体架构



在我们的架构中，一个网元分为三层，分别是应用层、网络层与物理层。整体设7网元（1路由+2交换+4终端）。

发送终端

- 应用层：与用户交互信息，并将信息编码：包括传输的字符串，网元所处的模式（接收、单播、广播），单播中的目的地地址。
- 网络层：进行封装：包括帧头帧尾的定位码，源和目的地的地址码，帧序号，CRC校验码。
- 物理层：使用课程提供的物理层模拟软件，实现比特流传输。

接收终端

- 物理层：使用课程提供的物理层模拟软件，实现比特流传输。
- 网络层：依靠定位码定位帧始末位置，读取目的地地址。
 - 如果目的地是本机，则继续读取源地址、帧序号，并使用CRC校验码检错，有可能要求重传。
 - 如果目的地不是本机，则进行转发。
- 应用层：解码比特流，呈现给用户可读信息。

交换机与路由器

由于交换机与路由器不是用户交互的对象，所以不设应用层，但仍会在捕获比特流时，显示必要的debug信息。

在传输信息时，他们会读取目的地地址，交换机判断下一步路径，路由器则进行简单的转发。

阶段一代码

服务器

```
/**
 * @name: server.cpp
 * @author: 蔡与望, 党一琨, 郭培琪, 陶砚青
 * @description:
 * 接收客户端的随机数, 并产生新随机数; 如果总和超过上限, 则将总和返回给客户端。
 */
#include <ctime>
#include <iostream>
#include <winsock2.h>
#include <windows.h>
using namespace std;

#define MAX_BUFFER_SIZE 512
#define SUM_BORDER 100

int main(int argc, char *argv[]) {
    // 随机数的随机种子。
    srand(time(NULL));

    // 初始化 DLL 与网络库。
    WSADATA wsaData;
    int state = WSASStartup(MAKEWORD(2, 2), &wsaData);
    if (state != 0) {
        cout << "Error: WSASStartup() failed. (" << WSAGetLastError() << ")"
            << endl;
        return -1;
    }

    // 创建服务器套接字。
    SOCKET serverSocket = socket(AF_INET, SOCK_STREAM, IPPROTO_TCP);
    if (serverSocket == INVALID_SOCKET) {
        cout << "Error: Invalid server socket. (" << WSAGetLastError() << ")"
            << endl;
        return -1;
    }

    // 确定服务器地址。
    SOCKADDR_IN serverAddress;
    int serverSize = sizeof(serverAddress);
    serverAddress.sin_family = AF_INET;
    serverAddress.sin_addr.S_un.S_addr = inet_addr("127.0.0.1");
    serverAddress.sin_port = htons(1234);

    // 绑定服务器套接字与地址。
    state = bind(serverSocket, (SOCKADDR *)&serverAddress, serverSize);
    if (state == SOCKET_ERROR) {
        cout << "Error: bind() failed. (" << WSAGetLastError() << ")" << endl;
        closesocket(serverSocket);
        return -1;
    }

    // 服务端开始监听。
    state = listen(serverSocket, 5);
    if (state == SOCKET_ERROR) {
        cout << "Error: listen() failed. (" << WSAGetLastError() << ")" << endl;
    }
}
```

```

        closesocket(serverSocket);
        return -1;
    }

    // 接受客户端连接请求，系统分配客户端端口号。
    SOCKADDR_IN clientAddress;
    int clientSize = sizeof(clientAddress);
    SOCKET clientSocket =
        accept(serverSocket, (SOCKADDR *)&clientAddress, &clientSize);
    if (clientSocket == INVALID_SOCKET) {
        cout << "Error: Invalid client socket. (" << WSAGetLastError() << ")"
            << endl;
        return -1;
    }
    cout << "Client connection accepted: " << inet_ntoa(clientAddress.sin_addr)
        << ":" << clientAddress.sin_port << endl;

    // 通知客户端其端口号。
    string portStr;
    portStr = to_string(clientAddress.sin_port);
    send(clientSocket, portStr.c_str(), portStr.length(), 0);

    // 开始与客户端通信。
    cout << "-----" << endl;
    char recvStr[MAX_BUFFER_SIZE];
    int returnCnt = 0;
    for (int index = 0; index < 20; index++) {
        // 清空接收区。
        memset(recvStr, '\0', sizeof(recvStr));
        // 接收客户端发来的数字。
        int recvLen = recv(clientSocket, recvStr, MAX_BUFFER_SIZE, 0);
        if (recvLen > 0)
            recvStr[recvLen] = '\0';
        else
            continue;
        int recvNum = atoi(recvStr);
        cout << index + 1 << "\tReceived: " << recvNum;
        // 产生随机数并相加。
        int randNum = rand() % 500 + 1;
        cout << "\tGenerated: " << randNum << endl;
        int sum = recvNum + randNum;
        // 如果超过上限，则把结果返回客户端。
        if (sum > SUM_BORDER) {
            string sumStr = to_string(sum);
            send(clientSocket, sumStr.c_str(), sumStr.length(), 0);
            returnCnt++;
        }
    }
}

// 关闭服务。
closesocket(serverSocket);
WSACleanup();
cout << "-----" << endl;
cout << "Server closed. " << endl;
cout << returnCnt << " return(s), time expected: " << 10 - 0.5 * returnCnt
    << " second(s)." << endl
    << endl;
return 0;

```

```
}
```

客户端

```
/**
 * @name: client.cpp
 * @author: 蔡与望, 党一琨, 郭培琪, 陶砚青
 * @description:
 * 每`500ms`向服务器发送一个随机数, 如果服务器有返回则立刻发送新随机数。
 */
#include <ctime>
#include <iostream>
#include <winsock2.h>
#include <windows.h>
using namespace std;

#define MAX_BUFFER_SIZE 512

int main(int argc, char *argv[]) {
    // 随机数的随机种子。
    srand(time(NULL));
    // 超时`500ms`未接到服务器返回值, 则发送下一个数字。
    TIMEVAL timeout = {0, 500000};
    // 计时器。
    clock_t start, end;

    // 初始化 DLL 与网络库。
    WSADATA wsaData;
    int state = WSASStartup(MAKEWORD(2, 2), &wsaData);
    if (state != 0) {
        cout << "Error: WSASStartup() failed. (" << WSAGetLastError() << ")"
             << endl;
        return -1;
    }

    // 创建客户端套接字。
    SOCKET clientSocket = socket(AF_INET, SOCK_STREAM, IPPROTO_TCP);
    if (clientSocket == INVALID_SOCKET) {
        cout << "Error: Invalid client socket. (" << WSAGetLastError() << ")"
             << endl;
        return -1;
    }

    // 输入服务器地址。
    string serverIp = "";
    int serverPort = 0;
    cout << "Server IP: ";
    cin >> serverIp;
    cout << "Server port: ";
    cin >> serverPort;
    SOCKADDR_IN serverAddress;
    int serverSize = sizeof(serverAddress);
    serverAddress.sin_family = AF_INET;
    serverAddress.sin_addr.S_un.S_addr = inet_addr(serverIp.c_str());
    serverAddress.sin_port = htons(serverPort);

    // 客户端套接字绑定服务器地址。
```

```

state = connect(clientSocket, (SOCKADDR *)&serverAddress, serverSize);
if (state == SOCKET_ERROR) {
    cout << "Error: connect() failed. (" << WSAGetLastError() << ")"
        << endl;
    closesocket(clientSocket);
    return -1;
}

// 接收分配到的端口号。
char portStr[5];
recv(clientSocket, portStr, 5, 0);
cout << "Client port at: " << portStr << endl;

// 开始与服务器通信。
cout << "-----" << endl;
char sumStr[MAX_BUFFER_SIZE];
FD_SET rfd;
start = clock();
for (int index = 0; index < 20; index++) {
    // 清空接收区。
    memset(sumStr, '\0', sizeof(sumStr));
    // 产生随机数并发送。
    string sendStr = to_string(rand() % 500 + 1);
    cout << index + 1 << "\tGenerated: " << sendStr;
    send(clientSocket, sendStr.c_str(), sendStr.length(), 0);
    // 可能要接收服务器的返回值。
    FD_ZERO(&rfd);
    FD_SET(clientSocket, &rfd);
    int readyNum = select(0, &rfd, NULL, NULL, &timeout);
    if (!readyNum)
        cout << endl;
    else {
        recv(clientSocket, sumStr, MAX_BUFFER_SIZE, 0);
        cout << "\tSum: " << atoi(sumStr) << endl;
    }
}
end = clock();

// 关闭服务。
closesocket(clientSocket);
WSACleanup();
cout << "-----" << endl;
cout << "Client closed." << endl;
cout << "Session cost " << (double)(end - start) / CLOCKS_PER_SEC
    << " second(s)." << endl
    << endl;
return 0;
}

```

运行截图

```
PS D:\Codes\CNTProject1\Stage1> g++ -g server.cpp -o server -lws2_32; ./serve
r
Client connection accepted: 127.0.0.1:63684
-----
1 Received: 286 Generated: 196
2 Received: 311 Generated: 333
3 Received: 41 Generated: 484
4 Received: 407 Generated: 253
5 Received: 52 Generated: 377
6 Received: 145 Generated: 133
7 Received: 296 Generated: 458
8 Received: 372 Generated: 154
9 Received: 48 Generated: 58
10 Received: 133 Generated: 77
11 Received: 321 Generated: 265
12 Received: 26 Generated: 393
13 Received: 78 Generated: 198
14 Received: 376 Generated: 5
15 Received: 53 Generated: 13
16 Received: 445 Generated: 467
17 Received: 484 Generated: 254
18 Received: 148 Generated: 488
19 Received: 338 Generated: 114
20 Received: 355 Generated: 317
-----
Server closed.
18 return(s), time expected: 1 second(s).

PS D:\Codes\CNTProject1\Stage1>

PS D:\Codes\CNTProject1\Stage1> g++ -g client.cpp -o client -lws2_32; ./clien
t
Server IP: 127.0.0.1
Server port: 1234
Client port at: 63684
-----
1 Generated: 286 Sum: 482
2 Generated: 311 Sum: 644
3 Generated: 41 Sum: 525
4 Generated: 407 Sum: 668
5 Generated: 52 Sum: 429
6 Generated: 145 Sum: 278
7 Generated: 296 Sum: 754
8 Generated: 372 Sum: 526
9 Generated: 48
10 Generated: 133 Sum: 210
11 Generated: 321 Sum: 586
12 Generated: 26 Sum: 419
13 Generated: 78 Sum: 276
14 Generated: 376 Sum: 381
15 Generated: 53
16 Generated: 445 Sum: 912
17 Generated: 484 Sum: 658
18 Generated: 148 Sum: 556
19 Generated: 338 Sum: 452
20 Generated: 355 Sum: 672
-----
Client closed.
Session cost 1.029 second(s).

PS D:\Codes\CNTProject1\Stage1>
```

可以看到，服务端与客户端之间能够进行稳定的通信，客户端通过 `select` 实现了超时的判断，实际运行时间与预期时间（ $10 \cdot 0.5N$ ）大致相符。