



警示

- 1.实验报告如有雷同，雷同各方当次实验成绩均以 0 分计。
- 2.当次小组成员成绩只计学号、姓名登录在下表中的。
- 3.在规定时间内未上交实验报告的，不得以其他方式补交，当次成绩按 0 分计。
- 4.实验报告文件以 PDF 格式提交。

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编程实验

【实验内容】

(1) 完成实验教程实例 3-2 的实验（考虑局域网、互联网两种实验环境），回答实验提出的问题及实验思考。（P103）。

答：见【代码设计与分析】，【实验过程与结果分析】，【思考题解答】三部分。

(2) 注意实验时简述设计思路。

答：见【代码设计与分析】。

(3) 引起 UDP 丢包的可能原因是什么？

答：① 客户端发包频率过快或者发送包的报文太大（可在客户端发送数据包的 while 循环里调用 Sleep(1) 函数来降低发包频率）；

② 服务端处理或接收包的速度太慢，导致部分包未能接收到（如服务端缓冲区容量太小或调用 recvfrom 函数的效率太低）；

③ UDP 本身不安全的性质就决定了该协议出现丢包现象的频率会高于 TCP。

【实验目的】

选择一个操作系统环境（Linux 或者 Windows），编制 UDP 通信程序，完成一定的通信功能。

【代码设计与分析】

在 Windows 下实现网络编程我们要加入头文件 winsock2.h，同时我们在编译的时候需要连接 ws2_32 库文件。

在本实验中我们使用 2.2 版本下链接库的 socket 函数，为实现这一目的，我们加入以下语句：

```
WSADATA data;  
int state = WSStartup(MAKEWORD(2,2),&data);
```



下面我们分别就服务端和客户端对程序进行分析。

一、服务端（Server）

1、建立句柄

```
SOCKET word = socket(PF_INET, SOCK_DGRAM, IPPROTO_UDP);
```

2、开启一个端口同时与客户端的一个端口绑定

```
struct sockaddr_in my_socket;  
struct sockaddr_in from;           //sender address  
int fromsize = sizeof(from);  
my_socket.sin_family = AF_INET;  
my_socket.sin_port = htons(10000);  
my_socket.sin_addr.s_addr = INADDR_ANY;  
if(bind(word, (LPSOCKADDR)&my_socket, sizeof(my_socket)) == SOCKET_ERROR) {  
    printf("bind error\n");  
    return 0;  
}
```

3、接收数据包并打印相应信息

```
while(1){  
    fflush(stdout);  
    int cc = recvfrom(word, rev, 100, 0, (SOCKADDR *)&from, &fromsize);  
    if (cc == SOCKET_ERROR){  
        printf("recvfrom() failed; %d\n", WSAGetLastError());  
        break;  
    }  
    else if (cc == 0)  
        break;  
    else{  
        size++;  
        rev[cc] = '\0';  
        printf("The server is receiving.....\n");  
        printf("The content of the package for this time is: %s\n", rev);  
        printf("The number of received packages is %d in total.\n\n", size-1);  
    }  
}
```

4、清除句柄和数据连接

```
closesocket(word);  
WSACleanup();
```



二、客户端 (Client)

1、建立句柄

```
SOCKET word = socket(PF_INET, SOCK_DGRAM, IPPROTO_UDP);
```

2、根据 IP 地址连接服务器，并确定端口

```
struct sockaddr_in my_socket;  
  
my_socket.sin_family = AF_INET;  
my_socket.sin_port = htons(10000);  
//my_socket.sin_addr.s_addr = inet_addr("49.232.4.77"); //互联网 IP  
my_socket.sin_addr.s_addr = inet_addr("192.168.43.66");//局域网 IP
```

3、向服务器发送消息

```
int size;  
printf("Please enter the number of packages you are ready to send:\n");  
scanf("%d",&size);  
for(int i = 0;i < size;++ i) {  
    char buf[30];  
    char num[10];  
    strcpy(buf,"Package ");  
    itoa(i,num,10);  
    strcat(buf,num);  
    int cc = sendto(word, buf, strlen(buf), 0,(SOCKADDR *)&my_socket, sizeof(my_socket  
));  
    if (cc == SOCKET_ERROR){  
        printf("send error\n");  
        return 0;  
    }  
    //Sleep(1)//使每个包之间的发送时间间隔 1ms，达到缓冲的效果，减少因数据发送太快而导致的丢包  
}
```

4、清除句柄和数据连接

```
closesocket(word);  
WSACleanup();
```



完整代码如下：

服务端：

```
#include<time.h>
#include<windows.h>
#include<winsock2.h>
#include<string.h>
#include<stdio.h>
#include<stdlib.h>
#pragma comment(lib,"ws2_32.lib");

int main() {
    WSADATA data;
    int state = WSStartup(MAKEWORD(2,2),&data);
    if(state != 0) {
        printf("initial error\n");
        return 0;
    }
    SOCKET word = socket(PF_INET, SOCK_DGRAM,IPPROTO_UDP);
    if(word == INVALID_SOCKET) {
        printf("socket error\n");
        return 0;
    }
    struct sockaddr_in my_socket;
    struct sockaddr_in from;          //sender address
    int fromsize = sizeof(from);
    my_socket.sin_family = AF_INET;
    my_socket.sin_port = htons(10000); //开放和客户端一样的端口
    my_socket.sin_addr.s_addr = INADDR_ANY;
    if(bind(word,(LPSOCKADDR)&my_socket,sizeof(my_socket)) == SOCKET_ERROR) {
        printf("bind error\n");
        return 0;
    }
    char rev[64];
    int size = 0;
    char res[50];
    int result;
    while(1){
        fflush(stdout); //每次接收前先清空并输出当前缓冲区
        int cc = recvfrom(word, rev,100, 0, (SOCKADDR *)&from, &fromsize); //接收客户端数据
        if (cc == SOCKET_ERROR){
            printf("recvfrom() failed; %d\n", WSAGetLastError());
            break;
        }
    }
}
```

包



```
}
else if (cc == 0)
    break;
else{
    size ++;
    rev[cc] = '\0';
    printf("The server is receiving.....\n");
    printf("The content of the package for this time is: %s\n",rev);
    printf("The number of received packages is %d in total.\n\n",size);
}
}
closesocket(word);
WSACleanup();
}
```

客户端:

```
#include<string.h>
#include<stdio.h>
#include<stdlib.h>
#include<winsock2.h>
#include<windows.h>
#pragma comment(lib,"ws2_32.lib")

int main() {
    WSADATA data;
    int state = WSStartup(MAKEWORD(2,2),&data);//初始化
    if(state != 0) {
        printf("initial error\n");
        return 0;
    }
    SOCKET word = socket(PF_INET, SOCK_DGRAM,IPPROTO_UDP);//初始化套接字
    if(word == INVALID_SOCKET) {
        printf("socket error\n");
        return 0;
    }
    struct sockaddr_in my_socket;

    my_socket.sin_family = AF_INET;
    my_socket.sin_port = htons(10000);
    my_socket.sin_addr.s_addr = inet_addr("49.232.4.77"); //互联网 IP
    //my_socket.sin_addr.s_addr = inet_addr("192.168.43.66");//局域网 IP

    int size;
```



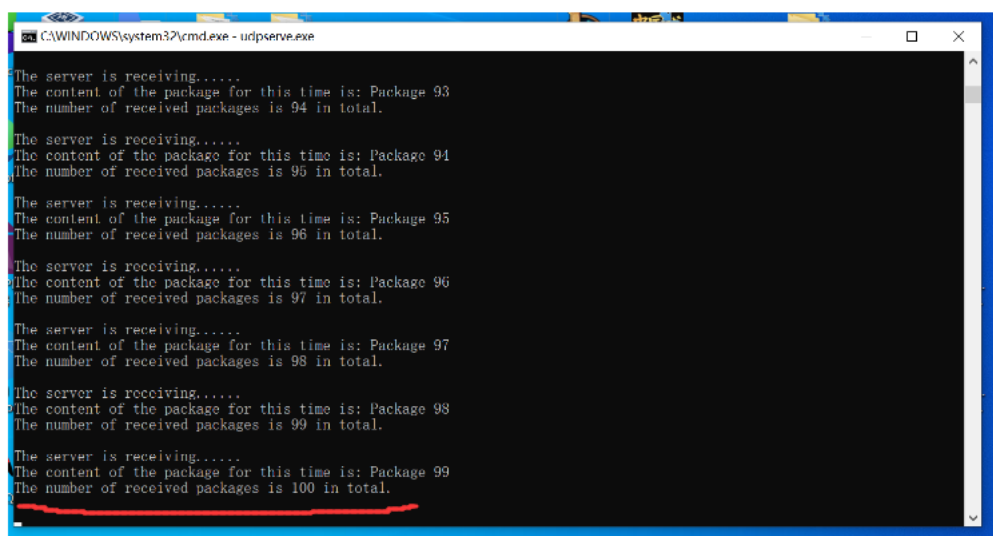
```
printf("Please enter the number of packages you are ready to send:\n");
scanf("%d",&size);//选择要发送的包的数量
for(int i=1;i<=size;i++){
    char buf[30];
    char num[10];
    strcpy(buf,"Package ");
    itoa(i,num,10);
    strcat(buf,num);//此时 buf 的内容为最终发送内容: "Package X"
    int cc = sendto(word, buf, strlen(buf), 0,(SOCKADDR *)&my_socket, sizeof(my_socket));
    //发送包到服务端
    if (cc == SOCKET_ERROR){
        printf("send error\n");
        return 0;
    }
    //Sleep(1)//使每个包之间的发送时间间隔 1ms, 达到缓冲的效果, 减少因数据发送太快而导致的丢包
}
closesocket(word);
WSACleanup();
}
```

【实验过程与结果分析】

① 在局域网上进行 UDP 传输:

我们选择了宿舍的两台 PC 分别作为服务端和客户端, 并且连接同一个手机热点进行传输, 最后我们在作为服务端的 PC 上运行 wireshark 进行抓包, 结果如下所示:

(1) 发送 100 个数据包的情况, 我们共进行了 3 次实验, 结果如下:





udp and ip.addr==172.18.53.63 and ip.addr==172.26.26.238

No.	Time	Source	Destination	Protocol	Length	Info
14	3.321230	172.18.53.63	172.26.26.238	UDP	60	63712 → 10000 Len=9
15	3.321230	172.18.53.63	172.26.26.238	UDP	60	63712 → 10000 Len=9
16	3.321230	172.18.53.63	172.26.26.238	UDP	60	63712 → 10000 Len=9
17	3.321230	172.18.53.63	172.26.26.238	UDP	60	63712 → 10000 Len=9
18	3.321230	172.18.53.63	172.26.26.238	UDP	60	63712 → 10000 Len=9
19	3.321230	172.18.53.63	172.26.26.238	UDP	60	63712 → 10000 Len=9
20	3.321230	172.18.53.63	172.26.26.238	UDP	60	63712 → 10000 Len=9
21	3.321230	172.18.53.63	172.26.26.238	UDP	60	63712 → 10000 Len=9
22	3.321230	172.18.53.63	172.26.26.238	UDP	60	63712 → 10000 Len=9
23	3.321230	172.18.53.63	172.26.26.238	UDP	60	63712 → 10000 Len=9
24	3.321230	172.18.53.63	172.26.26.238	UDP	60	63712 → 10000 Len=10
25	3.321230	172.18.53.63	172.26.26.238	UDP	60	63712 → 10000 Len=10
26	3.321230	172.18.53.63	172.26.26.238	UDP	60	63712 → 10000 Len=10
27	3.321230	172.18.53.63	172.26.26.238	UDP	60	63712 → 10000 Len=10
28	3.321230	172.18.53.63	172.26.26.238	UDP	60	63712 → 10000 Len=10
29	3.321230	172.18.53.63	172.26.26.238	UDP	60	63712 → 10000 Len=10
30	3.321629	172.18.53.63	172.26.26.238	UDP	60	63712 → 10000 Len=10
31	3.321629	172.18.53.63	172.26.26.238	UDP	60	63712 → 10000 Len=10
32	3.321629	172.18.53.63	172.26.26.238	UDP	60	63712 → 10000 Len=10

> Frame 14: 60 bytes on wire (480 bits), 60 bytes captured (480 bits) on interface \Device\NPF_{B492BCAB-24D9-4611-94A8-5C74E4A9E7CA}, id 0
> Ethernet II, Src: Ruijiele_9f:46:87 (00:74:9c:9f:46:87), Dst: LiteonTe_e8:56:5f (30:d1:6b:e8:56:5f)
> Internet Protocol Version 4, Src: 172.18.53.63, Dst: 172.26.26.238
> User Datagram Protocol, Src Port: 63712, Dst Port: 10000
> Data (9 bytes)

0000 30 d1 6b e8 56 5f 00 74 9c 9f 46 87 08 00 45 00 0-k-V..t...F...E..
0010 00 25 24 7f 00 00 7c 11 71 ef ac 12 35 3f 0c 1a %\$...|..q...5?...
0020 1a ee e5 37 27 10 00 11 a0 d5 50 61 63 6b 61 67 ...7'....Packag
0030 65 20 30 00 00 00 00 00 00 00 00 00 00 00 00 e 0.....

100.1.pcapng 分组: 176 • 已显示: 100 (56.8%) 配置: Default

```
C:\WINDOWS\system32\cmd.exe - udpsrv.exe

The server is receiving.....
The content of the package for this time is: Package 93
The number of received packages is 94 in total.

The server is receiving.....
The content of the package for this time is: Package 94
The number of received packages is 95 in total.

The server is receiving.....
The content of the package for this time is: Package 95
The number of received packages is 96 in total.

The server is receiving.....
The content of the package for this time is: Package 96
The number of received packages is 97 in total.

The server is receiving.....
The content of the package for this time is: Package 97
The number of received packages is 98 in total.

The server is receiving.....
The content of the package for this time is: Package 98
The number of received packages is 99 in total.

The server is receiving.....
The content of the package for this time is: Package 99
The number of received packages is 100 in total.
```

udp and ip.addr==172.18.53.63 and ip.addr==172.26.26.238

No.	Time	Source	Destination	Protocol	Length	Info
108	4.159606	172.18.53.63	172.26.26.238	UDP	60	58679 → 10000 Len=9
109	4.159606	172.18.53.63	172.26.26.238	UDP	60	58679 → 10000 Len=9
110	4.159606	172.18.53.63	172.26.26.238	UDP	60	58679 → 10000 Len=9
111	4.159606	172.18.53.63	172.26.26.238	UDP	60	58679 → 10000 Len=9
112	4.159606	172.18.53.63	172.26.26.238	UDP	60	58679 → 10000 Len=9
113	4.159606	172.18.53.63	172.26.26.238	UDP	60	58679 → 10000 Len=9
114	4.159606	172.18.53.63	172.26.26.238	UDP	60	58679 → 10000 Len=9
115	4.159606	172.18.53.63	172.26.26.238	UDP	60	58679 → 10000 Len=9
116	4.159606	172.18.53.63	172.26.26.238	UDP	60	58679 → 10000 Len=9
117	4.159606	172.18.53.63	172.26.26.238	UDP	60	58679 → 10000 Len=9
118	4.159606	172.18.53.63	172.26.26.238	UDP	60	58679 → 10000 Len=10
119	4.159606	172.18.53.63	172.26.26.238	UDP	60	58679 → 10000 Len=10
120	4.159606	172.18.53.63	172.26.26.238	UDP	60	58679 → 10000 Len=10
121	4.159606	172.18.53.63	172.26.26.238	UDP	60	58679 → 10000 Len=10
122	4.159606	172.18.53.63	172.26.26.238	UDP	60	58679 → 10000 Len=10
123	4.159606	172.18.53.63	172.26.26.238	UDP	60	58679 → 10000 Len=10
124	4.159919	172.18.53.63	172.26.26.238	UDP	60	58679 → 10000 Len=10
125	4.159919	172.18.53.63	172.26.26.238	UDP	60	58679 → 10000 Len=10
126	4.159919	172.18.53.63	172.26.26.238	UDP	60	58679 → 10000 Len=10

> Frame 108: 60 bytes on wire (480 bits), 60 bytes captured (480 bits) on interface \Device\NPF_{B492BCAB-24D9-4611-94A8-5C74E4A9E7CA}, id 0
> Ethernet II, Src: Ruijiele_9f:46:87 (00:74:9c:9f:46:87), Dst: LiteonTe_e8:56:5f (30:d1:6b:e8:56:5f)
> Internet Protocol Version 4, Src: 172.18.53.63, Dst: 172.26.26.238
> User Datagram Protocol, Src Port: 58679, Dst Port: 10000
> Data (9 bytes)

0000 30 d1 6b e8 56 5f 00 74 9c 9f 46 87 08 00 45 00 0-k-V..t...F...E..
0010 00 25 24 e3 00 00 7c 11 71 8b ac 12 35 3f ac 1a %\$...|..q...5?...
0020 1a ee e5 37 27 10 00 11 a0 d5 50 61 63 6b 61 67 ...7'....Packag
0030 65 20 30 00 00 00 00 00 00 00 00 00 00 00 00 e 0.....

100.2.pcapng 分组: 1034 • 已显示: 100 (9.7%) 配置: Default



```
CA\WINDOWS\system32\cmd.exe - udpserve.exe
The server is receiving.....
The content of the package for this time is: Package 93
The number of received packages is 91 in total.

The server is receiving.....
The content of the package for this time is: Package 94
The number of received packages is 95 in total.

The server is receiving.....
The content of the package for this time is: Package 95
The number of received packages is 96 in total.

The server is receiving.....
The content of the package for this time is: Package 96
The number of received packages is 97 in total.

The server is receiving.....
The content of the package for this time is: Package 97
The number of received packages is 98 in total.

The server is receiving.....
The content of the package for this time is: Package 98
The number of received packages is 99 in total.

The server is receiving.....
The content of the package for this time is: Package 99
The number of received packages is 100 in total.
```

udp and ip.addr==172.18.53.63 and ip.addr==172.26.26.238

No.	Time	Source	Destination	Protocol	Length	Info
189	9.324054	172.18.53.63	172.26.26.238	UDP	60	49298 → 10000 Len=9
190	9.324054	172.18.53.63	172.26.26.238	UDP	60	49298 → 10000 Len=9
191	9.324054	172.18.53.63	172.26.26.238	UDP	60	49298 → 10000 Len=9
192	9.324054	172.18.53.63	172.26.26.238	UDP	60	49298 → 10000 Len=9
193	9.324054	172.18.53.63	172.26.26.238	UDP	60	49298 → 10000 Len=9
194	9.324054	172.18.53.63	172.26.26.238	UDP	60	49298 → 10000 Len=9
195	9.324054	172.18.53.63	172.26.26.238	UDP	60	49298 → 10000 Len=9
196	9.324054	172.18.53.63	172.26.26.238	UDP	60	49298 → 10000 Len=9
197	9.324054	172.18.53.63	172.26.26.238	UDP	60	49298 → 10000 Len=9
198	9.324054	172.18.53.63	172.26.26.238	UDP	60	49298 → 10000 Len=9
199	9.324054	172.18.53.63	172.26.26.238	UDP	60	49298 → 10000 Len=10
200	9.324054	172.18.53.63	172.26.26.238	UDP	60	49298 → 10000 Len=10
201	9.324054	172.18.53.63	172.26.26.238	UDP	60	49298 → 10000 Len=10
202	9.324054	172.18.53.63	172.26.26.238	UDP	60	49298 → 10000 Len=10
203	9.324054	172.18.53.63	172.26.26.238	UDP	60	49298 → 10000 Len=10
204	9.324054	172.18.53.63	172.26.26.238	UDP	60	49298 → 10000 Len=10
205	9.324054	172.18.53.63	172.26.26.238	UDP	60	49298 → 10000 Len=10
206	9.324354	172.18.53.63	172.26.26.238	UDP	60	49298 → 10000 Len=10
207	9.324354	172.18.53.63	172.26.26.238	UDP	60	49298 → 10000 Len=10

> Frame 189: 60 bytes on wire (480 bits), 60 bytes captured (480 bits) on interface \Device\NPF_{B4928CAB-24D9-4611-9A48-5C74E4A9E7CA}, id 0
> Ethernet II, Src: Ruijiele_9f:46:87 (00:74:9c:9f:46:87), Dst: Liteon_e8:56:5f (30:d1:6b:e8:56:5f)
> Internet Protocol Version 4, Src: 172.18.53.63, Dst: 172.26.26.238
> User Datagram Protocol, Src Port: 49298, Dst Port: 10000
> Data (9 bytes)
0000 30 d1 6b e8 56 5f 00 74 9c 9f 46 87 08 00 45 00 0 k V _ t . . F . . E .
0010 00 25 25 47 00 00 7c 11 71 27 ac 12 35 3f ac 1a 88g . . | . q . . S . .
0020 1a ee c8 92 27 18 00 11 c5 7a 50 c1 63 60 c1 67 zPackag
0030 65 20 30 00 00 00 00 00 00 00 00 00 00 00 00 00 e 0

100.3.pcapng 分组: 344 • 已显示: 100 (29.1%) 配置: Default

综上，局域网下 UDP 发送 100 个包的丢包率为 0%。

(2) 为使实验严谨，我们额外进行了 3 次发送 10000 个数据包的抓包检测，结果如下：

```
CA\WINDOWS\system32\cmd.exe - udpserve.exe
The content of the package for this time is: Package 8917
The number of received packages is 2217 in total.

The server is receiving.....
The content of the package for this time is: Package 8918
The number of received packages is 2218 in total.

The server is receiving.....
The content of the package for this time is: Package 8919
The number of received packages is 2219 in total.

The server is receiving.....
The content of the package for this time is: Package 8920
The number of received packages is 2220 in total.

The server is receiving.....
The content of the package for this time is: Package 8921
The number of received packages is 2221 in total.

The server is receiving.....
The content of the package for this time is: Package 8922
The number of received packages is 2222 in total.

The server is receiving.....
The content of the package for this time is: Package 8923
The number of received packages is 2223 in total.

C:\Users\93508\Desktop>udpserve.exe
```




udp and ip.addr==172.18.53.63 and ip.addr==172.26.26.238						
No.	Time	Source	Destination	Protocol	Length	Info
422	8.482370	172.18.53.63	172.26.26.238	UDP	60	49303 → 10000 Len=9
423	8.482370	172.18.53.63	172.26.26.238	UDP	60	49303 → 10000 Len=9
424	8.482370	172.18.53.63	172.26.26.238	UDP	60	49303 → 10000 Len=9
425	8.482370	172.18.53.63	172.26.26.238	UDP	60	49303 → 10000 Len=9
426	8.482370	172.18.53.63	172.26.26.238	UDP	60	49303 → 10000 Len=9
427	8.482370	172.18.53.63	172.26.26.238	UDP	60	49303 → 10000 Len=9
428	8.482370	172.18.53.63	172.26.26.238	UDP	60	49303 → 10000 Len=9
429	8.482370	172.18.53.63	172.26.26.238	UDP	60	49303 → 10000 Len=9
430	8.482370	172.18.53.63	172.26.26.238	UDP	60	49303 → 10000 Len=9
431	8.482370	172.18.53.63	172.26.26.238	UDP	60	49303 → 10000 Len=9
432	8.482370	172.18.53.63	172.26.26.238	UDP	60	49303 → 10000 Len=10
433	8.482370	172.18.53.63	172.26.26.238	UDP	60	49303 → 10000 Len=10
434	8.482370	172.18.53.63	172.26.26.238	UDP	60	49303 → 10000 Len=10
435	8.482370	172.18.53.63	172.26.26.238	UDP	60	49303 → 10000 Len=10
436	8.482370	172.18.53.63	172.26.26.238	UDP	60	49303 → 10000 Len=10
437	8.482370	172.18.53.63	172.26.26.238	UDP	60	49303 → 10000 Len=10
438	8.482677	172.18.53.63	172.26.26.238	UDP	60	49303 → 10000 Len=10
439	8.482677	172.18.53.63	172.26.26.238	UDP	60	49303 → 10000 Len=10
440	8.482677	172.18.53.63	172.26.26.238	UDP	60	49303 → 10000 Len=10

> Frame 422: 60 bytes on wire (480 bits), 60 bytes captured (480 bits) on interface \Device\NPF_{B4928CAB-24D9-4611-9A48-5C74E4A9E7CA}, id 0
> Ethernet II, Src: RuijieHe_9f:46:87 (00:74:9c:9f:46:87), Dst: LiteonTe_e8:56:5f (30:d1:6b:e8:56:5f)
> Internet Protocol Version 4, Src: 172.18.53.63, Dst: 172.26.26.238
> User Datagram Protocol, Src Port: 49303, Dst Port: 10000
> Data (9 bytes)

0000 30 d1 6b e8 56 5f 00 74 9c 0f 46 87 08 00 45 00 0-k-V..t..F...E-
0010 00 25 2b ab 00 00 7c 11 70 c3 ac 12 35 3f ac 1a ..X...|..p...5?..
0020 1a ee c0 97 27 10 00 11 c5 75 50 61 63 6b 61 67uPackag
0030 65 20 30 00 00 00 00 00 00 00 00 00 00 00 00 00 e @.....

10000.1.pcapng || 分组: 2711 • 已显示: 2223 (82.0%) || 配置: Default

```
C:\WINDOWS\system32\cmd.exe - udpsrv.exe
6833 The server is receiving.....
6833 The content of the package for this time is: Package 8806
6833 The number of received packages is 3049 in total.
6833 The server is receiving.....
6833 The content of the package for this time is: Package 8807
6833 The number of received packages is 3050 in total.
6833 The server is receiving.....
6833 The content of the package for this time is: Package 8808
6833 The number of received packages is 3051 in total.
6833 The server is receiving.....
6833 The content of the package for this time is: Package 8809
6833 The number of received packages is 3052 in total.
6833 The server is receiving.....
6833 The content of the package for this time is: Package 8810
6833 The number of received packages is 3053 in total.
6833 The server is receiving.....
6833 The content of the package for this time is: Package 8811
6833 The number of received packages is 3054 in total.
6833 The server is receiving.....
6833 The content of the package for this time is: Package 8812
6833 The number of received packages is 3055 in total.
```

udp and ip.addr==172.18.53.63 and ip.addr==172.26.26.238						
No.	Time	Source	Destination	Protocol	Length	Info
166	3.168313	172.18.53.63	172.26.26.238	UDP	60	61428 → 10000 Len=9
167	3.168313	172.18.53.63	172.26.26.238	UDP	60	61428 → 10000 Len=9
168	3.168313	172.18.53.63	172.26.26.238	UDP	60	61428 → 10000 Len=9
169	3.168313	172.18.53.63	172.26.26.238	UDP	60	61428 → 10000 Len=9
170	3.168313	172.18.53.63	172.26.26.238	UDP	60	61428 → 10000 Len=9
171	3.168313	172.18.53.63	172.26.26.238	UDP	60	61428 → 10000 Len=9
172	3.168313	172.18.53.63	172.26.26.238	UDP	60	61428 → 10000 Len=9
173	3.168313	172.18.53.63	172.26.26.238	UDP	60	61428 → 10000 Len=9
174	3.168313	172.18.53.63	172.26.26.238	UDP	60	61428 → 10000 Len=9
175	3.168313	172.18.53.63	172.26.26.238	UDP	60	61428 → 10000 Len=9
176	3.168313	172.18.53.63	172.26.26.238	UDP	60	61428 → 10000 Len=10
177	3.168313	172.18.53.63	172.26.26.238	UDP	60	61428 → 10000 Len=10
178	3.168313	172.18.53.63	172.26.26.238	UDP	60	61428 → 10000 Len=10
179	3.168313	172.18.53.63	172.26.26.238	UDP	60	61428 → 10000 Len=10
180	3.168313	172.18.53.63	172.26.26.238	UDP	60	61428 → 10000 Len=10
181	3.168313	172.18.53.63	172.26.26.238	UDP	60	61428 → 10000 Len=10
182	3.168619	172.18.53.63	172.26.26.238	UDP	60	61428 → 10000 Len=10
183	3.168619	172.18.53.63	172.26.26.238	UDP	60	61428 → 10000 Len=10
184	3.168619	172.18.53.63	172.26.26.238	UDP	60	61428 → 10000 Len=10

> Frame 166: 60 bytes on wire (480 bits), 60 bytes captured (480 bits) on interface \Device\NPF_{B4928CAB-24D9-4611-9A48-5C74E4A9E7CA}, id 0
> Ethernet II, Src: RuijieHe_9f:46:87 (00:74:9c:9f:46:87), Dst: LiteonTe_e8:56:5f (30:d1:6b:e8:56:5f)
> Internet Protocol Version 4, Src: 172.18.53.63, Dst: 172.26.26.238
> User Datagram Protocol, Src Port: 61428, Dst Port: 10000
> Data (9 bytes)

0000 30 d1 6b e8 56 5f 00 74 9c 9f 46 87 08 00 45 00 0-k-V..t..F...E-
0010 00 25 4c bb 00 00 7c 11 49 b3 ac 12 35 3f ac 1a ..X...|..I...5?..
0020 1a ee ef f4 27 10 00 11 96 18 50 61 63 6b 61 67uPackag
0030 65 20 30 00 00 00 00 00 00 00 00 00 00 00 00 00 e @.....

10000.2.pcapng || 分组: 3380 • 已显示: 3055 (90.4%) || 配置: Default



```
C:\WINDOWS\system32\cmd.exe - udpserve.exe
77999
78001 The server is receiving.....
78003 The content of the package for this time is: Package 9993
78005 The number of received packages is 3314 in total.
78007
78009 The server is receiving.....
78011 The content of the package for this time is: Package 9994
78013 The number of received packages is 3315 in total.
78015
78017 The server is receiving.....
78019 The content of the package for this time is: Package 9995
78021 The number of received packages is 3316 in total.
78023
78025 The server is receiving.....
78027 The content of the package for this time is: Package 9996
78029 The number of received packages is 3317 in total.
78031
78033 The server is receiving.....
78035 The content of the package for this time is: Package 9997
78037 The number of received packages is 3318 in total.
78039
78041 The server is receiving.....
78043 The content of the package for this time is: Package 9998
78045 The number of received packages is 3319 in total.
78047
78049 The server is receiving.....
78051 The content of the package for this time is: Package 9999
78053 The number of received packages is 3320 in total.
78055
```

udp and ip.addr==172.18.53.63 and ip.addr==172.26.26.238						
No.	Time	Source	Destination	Protocol	Length	Info
82	7.659608	172.18.53.63	172.26.26.238	UDP	60	57173 → 10000 Len=9
83	7.659608	172.18.53.63	172.26.26.238	UDP	60	57173 → 10000 Len=9
84	7.659608	172.18.53.63	172.26.26.238	UDP	60	57173 → 10000 Len=9
85	7.659608	172.18.53.63	172.26.26.238	UDP	60	57173 → 10000 Len=9
86	7.659608	172.18.53.63	172.26.26.238	UDP	60	57173 → 10000 Len=9
87	7.659608	172.18.53.63	172.26.26.238	UDP	60	57173 → 10000 Len=9
88	7.659608	172.18.53.63	172.26.26.238	UDP	60	57173 → 10000 Len=9
89	7.659608	172.18.53.63	172.26.26.238	UDP	60	57173 → 10000 Len=9
90	7.659608	172.18.53.63	172.26.26.238	UDP	60	57173 → 10000 Len=9
91	7.659608	172.18.53.63	172.26.26.238	UDP	60	57173 → 10000 Len=9
92	7.659608	172.18.53.63	172.26.26.238	UDP	60	57173 → 10000 Len=10
93	7.659608	172.18.53.63	172.26.26.238	UDP	60	57173 → 10000 Len=10
94	7.659608	172.18.53.63	172.26.26.238	UDP	60	57173 → 10000 Len=10
95	7.659608	172.18.53.63	172.26.26.238	UDP	60	57173 → 10000 Len=10
96	7.659608	172.18.53.63	172.26.26.238	UDP	60	57173 → 10000 Len=10
97	7.659608	172.18.53.63	172.26.26.238	UDP	60	57173 → 10000 Len=10
98	7.659863	172.18.53.63	172.26.26.238	UDP	60	57173 → 10000 Len=10
99	7.659863	172.18.53.63	172.26.26.238	UDP	60	57173 → 10000 Len=10
100	7.659863	172.18.53.63	172.26.26.238	UDP	60	57173 → 10000 Len=10

> Frame 82: 60 bytes on wire (480 bits), 60 bytes captured (480 bits) on interface \Device\NPF_{B492BCAB-24D9-4611-94A8-5C74E4A9E7CA}, id 0

> Ethernet II, Src: Ruijiele_9f:46:87 (00:74:9c:9f:46:87), Dst: LiteonTe_e8:56:5f (30:d1:6b:e8:56:5f)

> Internet Protocol Version 4, Src: 172.18.53.63, Dst: 172.26.26.238

> User Datagram Protocol, Src Port: 57173, Dst Port: 10000

> Data (9 bytes)

0000 30 d1 6b e8 56 5f 00 74 9c 9f 46 87 00 00 45 00 0 k V . t . . F . . E .
0010 00 25 73 cb 00 00 7c 11 22 a3 ac 12 35 3f ac 1a 5a [. . . . 57 . .
0020 1a ee df 55 27 10 00 11 a6 b7 50 61 63 6b 61 67 . . . U Packag
0030 65 20 30 00 00 00 00 00 00 00 00 00 00 00 00 00 e @

10000.3.pcapng 分组: 3451 • 已显示: 3320 (96.2%) 配置: Default

$$\frac{7777 + 6945 + 6680}{10000 * 3} * 100\% = 71.34\%$$

综上，局域网下 UDP 发送 10000 个包的平均丢包率为 71.34%。也符合预期结果，即随着发送包数量的增加，丢包率也会增加，且丢包率会因为即时网络状况而产生波动（三次发送 10000 个包的丢包率均不同）。



② 在互联网上进行 UDP 传输：

我们选择了在腾讯云服务器上运行服务端程序，在本机上运行客户端程序，并在服务器上运行 wireshark 进行抓包，结果如下所示：

(1) 发送 100 个数据包的情况，我们共进行了 3 次实验，结果如下：

```
管理员: C:\Windows\system32\cmd.exe - udpserve.exe
The server is receiving.....
The content of the package for this time is: Package 95
The number of received packages is 95 in total.

The server is receiving.....
The content of the package for this time is: Package 96
The number of received packages is 96 in total.

The server is receiving.....
The content of the package for this time is: Package 97
The number of received packages is 97 in total.

The server is receiving.....
The content of the package for this time is: Package 98
The number of received packages is 98 in total.

The server is receiving.....
The content of the package for this time is: Package 99
The number of received packages is 99 in total.

The server is receiving.....
The content of the package for this time is: Package 100
The number of received packages is 100 in total.
```

No.	Time	Source	Destination	Protocol	Length	Info
132	8.342488	120.236.174.160	10.0.8.8	UDP	60	50470 → 10000 Len=9
133	8.342525	120.236.174.160	10.0.8.8	UDP	60	50470 → 10000 Len=9
134	8.342525	120.236.174.160	10.0.8.8	UDP	60	50470 → 10000 Len=9
135	8.342525	120.236.174.160	10.0.8.8	UDP	60	50470 → 10000 Len=9
136	8.342525	120.236.174.160	10.0.8.8	UDP	60	50470 → 10000 Len=9
137	8.342525	120.236.174.160	10.0.8.8	UDP	60	50470 → 10000 Len=9
138	8.342525	120.236.174.160	10.0.8.8	UDP	60	50470 → 10000 Len=9
139	8.342525	120.236.174.160	10.0.8.8	UDP	60	50470 → 10000 Len=9
140	8.342525	120.236.174.160	10.0.8.8	UDP	60	50470 → 10000 Len=9
141	8.342525	120.236.174.160	10.0.8.8	UDP	60	50470 → 10000 Len=10
142	8.342552	120.236.174.160	10.0.8.8	UDP	60	50470 → 10000 Len=10
143	8.342552	120.236.174.160	10.0.8.8	UDP	60	50470 → 10000 Len=10
144	8.342663	120.236.174.160	10.0.8.8	UDP	60	50470 → 10000 Len=10
145	8.342800	120.236.174.160	10.0.8.8	UDP	60	50470 → 10000 Len=10
146	8.342800	120.236.174.160	10.0.8.8	UDP	60	50470 → 10000 Len=10
147	8.342800	120.236.174.160	10.0.8.8	UDP	60	50470 → 10000 Len=10
148	8.342800	120.236.174.160	10.0.8.8	UDP	60	50470 → 10000 Len=10
149	8.342800	120.236.174.160	10.0.8.8	UDP	60	50470 → 10000 Len=10
150	8.342925	120.236.174.160	10.0.8.8	UDP	60	50470 → 10000 Len=10

> Frame 132: 60 bytes on wire (480 bits), 60 bytes captured (480 bits) on interface \Device\NPF_{EDA3259F-B1E6-4470-98A6-1F3E818AF93D}, Id 0
> Ethernet II, Src: fe8e:30:30:20:26 (fe8e:30:30:20:26), Dst: RealtekU_F5:61:22 (52:54:00:F5:61:22)
> Internet Protocol Version 4, Src: 120.236.174.160, Dst: 10.0.8.8
> User Datagram Protocol, Src Port: 50470, Dst Port: 10000
> Data (9 bytes)

0000 52 54 00 f5 61 22 fe ee 30 30 20 20 00 00 45 60 01...00 & Eh
0010 00 25 b2 52 00 00 31 11 92 39 78 ec ae a0 0a 00 8...1: 9x.....
0020 08 08 c5 26 27 10 00 11 2e ac 50 61 63 6b 61 07 8'...'Packag
0030 65 20 31 00 00 00 00 00 00 00 00 00 00 00 00 00 e 1.....

internet100.1.pcapng | 分组: 753 · 已显示: 100 (13.3%) | 配置: Default

```
管理员: C:\Windows\system32\cmd.exe - udpserve.exe
The server is receiving.....
The content of the package for this time is: Package 95
The number of received packages is 95 in total.

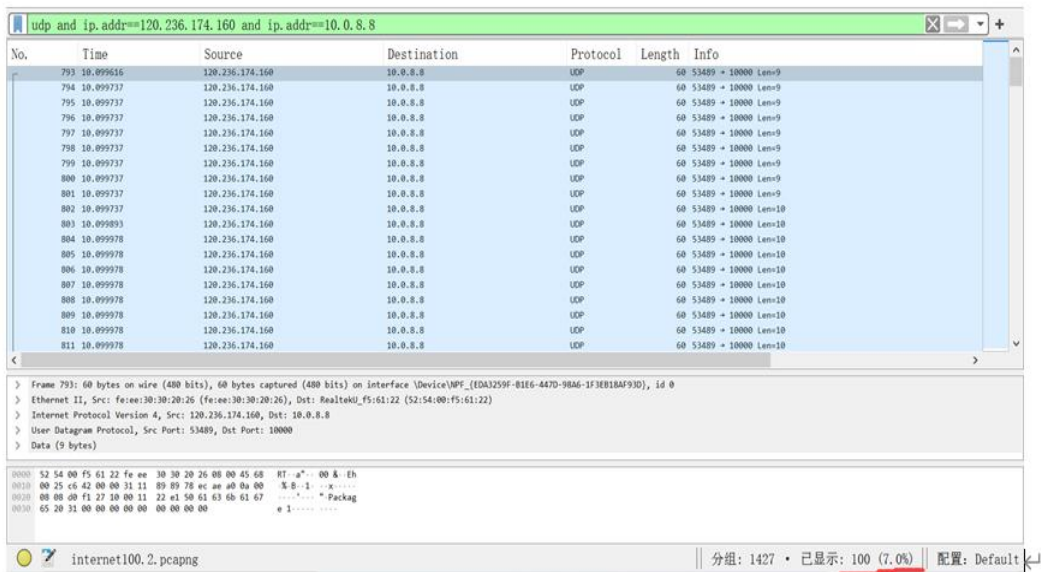
The server is receiving.....
The content of the package for this time is: Package 96
The number of received packages is 96 in total.

The server is receiving.....
The content of the package for this time is: Package 97
The number of received packages is 97 in total.

The server is receiving.....
The content of the package for this time is: Package 98
The number of received packages is 98 in total.

The server is receiving.....
The content of the package for this time is: Package 99
The number of received packages is 99 in total.

The server is receiving.....
The content of the package for this time is: Package 100
The number of received packages is 100 in total.
```



```
6. 174.160 10.0.8.8 UDP 60 4135
管理员: C:\Windows\system32\cmd.exe - udpserve.exe
The server is receiving.....
The content of the package for this time is: Package 95
The number of received packages is 95 in total.

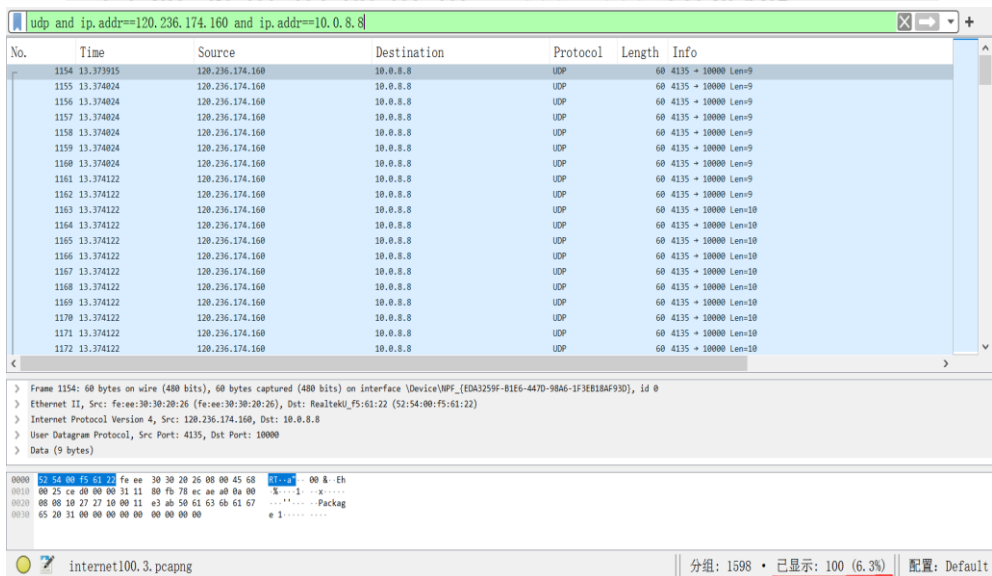
The server is receiving.....
The content of the package for this time is: Package 96
The number of received packages is 96 in total.

The server is receiving.....
The content of the package for this time is: Package 97
The number of received packages is 97 in total.

The server is receiving.....
The content of the package for this time is: Package 98
The number of received packages is 98 in total.

The server is receiving.....
The content of the package for this time is: Package 99
The number of received packages is 99 in total.

The server is receiving.....
The content of the package for this time is: Package 100
The number of received packages is 100 in total.
```



综上，互联网下 UDP 发送 100 个包的丢包率为 0%。



(2) 为使实验严谨，我们额外进行了 3 次发送 10000 个数据包的抓包检测，结果如下：

```
管理员: C:\Windows\system32\cmd.exe - udpserve.exe
The server is receiving.....
The content of the package for this time is: Package 9995
The number of received packages is 9995 in total.

The server is receiving.....
The content of the package for this time is: Package 9996
The number of received packages is 9996 in total.

The server is receiving.....
The content of the package for this time is: Package 9997
The number of received packages is 9997 in total.

The server is receiving.....
The content of the package for this time is: Package 9998
The number of received packages is 9998 in total.

The server is receiving.....
The content of the package for this time is: Package 9999
The number of received packages is 9999 in total.

The server is receiving.....
The content of the package for this time is: Package 10000
The number of received packages is 10000 in total.
```

udp and ip.addr==120.236.174.160 and ip.addr==10.0.8.8

No.	Time	Source	Destination	Protocol	Length	Info
200	5.545791	120.236.174.160	10.0.8.8	UDP	60	58902 → 10000 Len=9
201	5.545791	120.236.174.160	10.0.8.8	UDP	60	58902 → 10000 Len=9
202	5.545791	120.236.174.160	10.0.8.8	UDP	60	58902 → 10000 Len=9
203	5.545791	120.236.174.160	10.0.8.8	UDP	60	58902 → 10000 Len=9
204	5.545791	120.236.174.160	10.0.8.8	UDP	60	58902 → 10000 Len=9
205	5.545791	120.236.174.160	10.0.8.8	UDP	60	58902 → 10000 Len=9
206	5.545791	120.236.174.160	10.0.8.8	UDP	60	58902 → 10000 Len=9
207	5.545791	120.236.174.160	10.0.8.8	UDP	60	58902 → 10000 Len=9
208	5.545791	120.236.174.160	10.0.8.8	UDP	60	58902 → 10000 Len=9
209	5.545791	120.236.174.160	10.0.8.8	UDP	60	58902 → 10000 Len=10
210	5.545791	120.236.174.160	10.0.8.8	UDP	60	58902 → 10000 Len=10
211	5.545908	120.236.174.160	10.0.8.8	UDP	60	58902 → 10000 Len=10
212	5.545949	120.236.174.160	10.0.8.8	UDP	60	58902 → 10000 Len=10
213	5.546047	120.236.174.160	10.0.8.8	UDP	60	58902 → 10000 Len=10
214	5.546195	120.236.174.160	10.0.8.8	UDP	60	58902 → 10000 Len=10
215	5.546195	120.236.174.160	10.0.8.8	UDP	60	58902 → 10000 Len=10
216	5.546195	120.236.174.160	10.0.8.8	UDP	60	58902 → 10000 Len=10
217	5.546195	120.236.174.160	10.0.8.8	UDP	60	58902 → 10000 Len=10
218	5.546195	120.236.174.160	10.0.8.8	UDP	60	58902 → 10000 Len=10

> Frame 200: 60 bytes on wire (480 bits), 60 bytes captured (480 bits) on interface \Device\NPF_{EDA3259F-B1E6-447D-98A6-1F3E818AF930}, id 0
> Ethernet II, Src: fe:ee:30:30:20:26 (fe:ee:30:30:20:26), Dst: RealtekU_F5:61:22 (52:54:00:f5:61:22)
> Internet Protocol Version 4, Src: 120.236.174.160, Dst: 10.0.8.8
> User Datagram Protocol, Src Port: 58902, Dst Port: 10000
> Data (9 bytes)

0000 52 54 00 f5 61 22 fe ee 30 30 20 26 08 00 45 68 RT..a".00 &.Eh
0010 00 25 6c 90 00 00 31 11 e3 3b 78 ec ae a0 0a 00 .Xl..1..jx....
0020 00 08 e6 16 27 10 00 11 0d bc 50 c1 63 6b 61 67Packag
0030 65 20 31 00 00 00 00 00 00 00 00 00 e 1.....

internet 10000.1.pcapng 分组: 10546 • 已显示: 10000 (94.8%) 配置: Default

```
管理员: C:\Windows\system32\cmd.exe - udpserve.exe
The server is receiving.....
The content of the package for this time is: Package 9995
The number of received packages is 9850 in total.

The server is receiving.....
The content of the package for this time is: Package 9996
The number of received packages is 9851 in total.

The server is receiving.....
The content of the package for this time is: Package 9997
The number of received packages is 9852 in total.

The server is receiving.....
The content of the package for this time is: Package 9998
The number of received packages is 9853 in total.

The server is receiving.....
The content of the package for this time is: Package 9999
The number of received packages is 9854 in total.

The server is receiving.....
The content of the package for this time is: Package 10000
The number of received packages is 9855 in total.
```




No.	Time	Source	Destination	Protocol	Length	Info
1085	16.403754	120.236.174.160	10.0.8.8	UDP	60	29987 → 10000 Len=9
1086	16.403842	120.236.174.160	10.0.8.8	UDP	60	29987 → 10000 Len=9
1087	16.404026	120.236.174.160	10.0.8.8	UDP	60	29987 → 10000 Len=9
1088	16.404026	120.236.174.160	10.0.8.8	UDP	60	29987 → 10000 Len=9
1089	16.404026	120.236.174.160	10.0.8.8	UDP	60	29987 → 10000 Len=9
1090	16.404026	120.236.174.160	10.0.8.8	UDP	60	29987 → 10000 Len=9
1091	16.404026	120.236.174.160	10.0.8.8	UDP	60	29987 → 10000 Len=9
1092	16.404026	120.236.174.160	10.0.8.8	UDP	60	29987 → 10000 Len=9
1093	16.404026	120.236.174.160	10.0.8.8	UDP	60	29987 → 10000 Len=9
1094	16.404026	120.236.174.160	10.0.8.8	UDP	60	29987 → 10000 Len=10
1095	16.404026	120.236.174.160	10.0.8.8	UDP	60	29987 → 10000 Len=10
1096	16.404026	120.236.174.160	10.0.8.8	UDP	60	29987 → 10000 Len=10
1097	16.404026	120.236.174.160	10.0.8.8	UDP	60	29987 → 10000 Len=10
1098	16.404026	120.236.174.160	10.0.8.8	UDP	60	29987 → 10000 Len=10
1099	16.404026	120.236.174.160	10.0.8.8	UDP	60	29987 → 10000 Len=10
1100	16.404026	120.236.174.160	10.0.8.8	UDP	60	29987 → 10000 Len=10
1101	16.404026	120.236.174.160	10.0.8.8	UDP	60	29987 → 10000 Len=10
1102	16.404084	120.236.174.160	10.0.8.8	UDP	60	29987 → 10000 Len=10
1103	16.404084	120.236.174.160	10.0.8.8	UDP	60	29987 → 10000 Len=10

> Frame 1085: 60 bytes on wire (480 bits), 60 bytes captured (480 bits) on interface \Device\NPF_{EDA3259F-B1E6-447D-98A6-1F3E81BAF93D}, id 0
> Ethernet II, Src: feee:30:30:20:26 (feee:30:30:20:26), Dst: RealtekU_f5:61:22 (52:54:00:f5:61:22)
> Internet Protocol Version 4, Src: 120.236.174.160, Dst: 10.0.8.8
> User Datagram Protocol, Src Port: 29987, Dst Port: 10000
> Data (9 bytes)
0000 52 54 00 f5 61 22 fe ee 30 30 20 26 00 45 68 RT: a*... 00 & Eh
0010 00 25 36 ff 00 00 31 11 18 cd 78 ec ae a0 0a 00 36...:1...X...
0020 00 00 75 23 27 10 00 11 7e af 50 61 63 6b 61 67 ..u8...:Package
0030 65 20 31 00 00 00 00 00 00 00 00 e 1.....

internet10000.3.pcapng 分组: 11240 • 已显示: 9855 (87.7%) 配置: Default

```
管理员: C:\Windows\system32\cmd.exe - udpserve.exe
The server is receiving.....
The content of the package for this time is: Package 9995
The number of received packages is 9830 in total.

The server is receiving.....
The content of the package for this time is: Package 9996
The number of received packages is 9831 in total.

The server is receiving.....
The content of the package for this time is: Package 9997
The number of received packages is 9832 in total.

The server is receiving.....
The content of the package for this time is: Package 9998
The number of received packages is 9833 in total.

The server is receiving.....
The content of the package for this time is: Package 9999
The number of received packages is 9834 in total.

The server is receiving.....
The content of the package for this time is: Package 10000
The number of received packages is 9835 in total.
```

No.	Time	Source	Destination	Protocol	Length	Info
196	5.023613	120.236.174.160	10.0.8.8	UDP	60	54263 → 10000 Len=9
197	5.023613	120.236.174.160	10.0.8.8	UDP	60	54263 → 10000 Len=9
198	5.023613	120.236.174.160	10.0.8.8	UDP	60	54263 → 10000 Len=9
199	5.023613	120.236.174.160	10.0.8.8	UDP	60	54263 → 10000 Len=9
200	5.023613	120.236.174.160	10.0.8.8	UDP	60	54263 → 10000 Len=9
201	5.023613	120.236.174.160	10.0.8.8	UDP	60	54263 → 10000 Len=9
202	5.023613	120.236.174.160	10.0.8.8	UDP	60	54263 → 10000 Len=9
203	5.023613	120.236.174.160	10.0.8.8	UDP	60	54263 → 10000 Len=9
204	5.023613	120.236.174.160	10.0.8.8	UDP	60	54263 → 10000 Len=9
205	5.023613	120.236.174.160	10.0.8.8	UDP	60	54263 → 10000 Len=10
206	5.023613	120.236.174.160	10.0.8.8	UDP	60	54263 → 10000 Len=10
207	5.023613	120.236.174.160	10.0.8.8	UDP	60	54263 → 10000 Len=10
208	5.023717	120.236.174.160	10.0.8.8	UDP	60	54263 → 10000 Len=10
209	5.023717	120.236.174.160	10.0.8.8	UDP	60	54263 → 10000 Len=10
210	5.023717	120.236.174.160	10.0.8.8	UDP	60	54263 → 10000 Len=10
211	5.023717	120.236.174.160	10.0.8.8	UDP	60	54263 → 10000 Len=10
212	5.023717	120.236.174.160	10.0.8.8	UDP	60	54263 → 10000 Len=10
213	5.023717	120.236.174.160	10.0.8.8	UDP	60	54263 → 10000 Len=10
214	5.023717	120.236.174.160	10.0.8.8	UDP	60	54263 → 10000 Len=10

> Frame 196: 60 bytes on wire (480 bits), 60 bytes captured (480 bits) on interface \Device\NPF_{EDA3259F-B1E6-447D-98A6-1F3E81BAF93D}, id 0
> Ethernet II, Src: feee:30:30:20:26 (feee:30:30:20:26), Dst: RealtekU_f5:61:22 (52:54:00:f5:61:22)
> Internet Protocol Version 4, Src: 120.236.174.160, Dst: 10.0.8.8
> User Datagram Protocol, Src Port: 54263, Dst Port: 10000
> Data (9 bytes)
0000 52 54 00 f5 61 22 fe ee 30 30 20 26 00 45 68 RT: a*... 00 & Eh
0010 00 25 36 ff 00 00 31 11 c9 38 78 ec ae a0 0a 00 36...:1...X...
0020 00 00 d3 77 27 10 00 11 1e db 50 61 63 6b 61 67 ..:Package
0030 65 20 32 00 00 00 00 00 00 00 00 e 2.....

internet10000.4.pcapng 分组: 10705 • 已显示: 9835 (91.9%) 配置: Default

$$\frac{0 + 145 + 165}{10000 * 3} * 100\% = 1.033\%$$

综上，互联网下 UDP 发送 10000 个包的平均丢包率为 1.033%。也符合预期结果，即随着发送包数量的增加，丢包率也会增加，且丢包率会因为即时网络状况而产生波动（第一次发送 10000 个包未产生丢包，但后两次均发生不同数量的丢包）。



【思考题解答】

1. 说明在实验过程中遇到的问题和解决方法

答：（1）问题：客户端发送数据后，服务端收到数据并打印时打印出乱码。

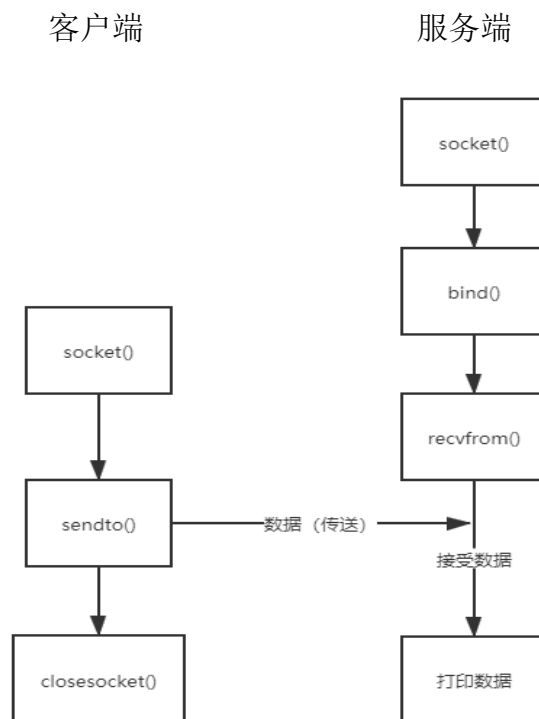
解决方法：最后通过网上查询资料和自行 debug 调试后找出解决方法：即字符串末尾设置为 0x00 即可。

（2）问题：互联网环境搭建失败，内网和外网的概念不清晰，一开始误以为一方校园网，一方手机热点或者两方连不同的手机热点就算互联网环境，但在运行程序时均出现 connect error 的情况。

解决方法：查阅资料了解内网外网概念，租借远程服务器完成互联网环境的搭建，并完成传输、抓包等实验内容。

2. 给出程序详细的流程图和对程序关键函数的详细说明

（1）程序流程图：



（2）程序关键函数说明：

```
SOCKET socket(int domain,int type,int protocol);
```

domain: 协议簇

type: 套接字类型

protocol: 协议簇中的协议号

返回值: 新创建的套接字句柄



```
int bind(SOCKET socket, struct sockaddr *address, int addr_len);
```

socket: 套接字

address: 本地地址 (包括服务器端口号)

addr_len: 地址长度

返回值: 0 (无错时), 或错误码

```
int sendto(SOCKET socket, const char * message, int len, int flags, const struct sockaddr* toa  
ddr, int tolen);
```

socket: 套接字

message: 要传送的信息

len: 信息长度

flags: 数据发送标记

toaddr: 指针, 指向目的套接字的地址

tolen: 所指地址的长度

返回值: 如果成功返回发送的字节数, 失败则返回 SOCKET_ERROR

```
int recvfrom(SOCKET socket, char *message, int len, int flags, struct sockaddr* from, int *from  
len);
```

socket: 套接字

message: 指向接受数据缓冲区

len: 缓冲区长度

flags: 调用操作方式

from: 指向装有原地址的缓冲区

fromlen: 指向 from 缓冲区长度值

返回值: 若无错误发生, 返回读入的字节数。如果连接已终止, 返回 0。否则返回 SOCKET_ERROR

3. 使用 Socket API 开发通信程序中的客户端程序和服务器程序时, 各需要哪些不同的函数

答: 客户端需要函数: socket(), sendto(), closesocket()

服务端需要函数: socket(), bind(), recvfrom(), closesocket()

4. 解释 connect(), bind() 等函数中 struct sockaddr * addr 参数各个部分的含义, 并用具体的数据举例说明

答: addr 实际指向的是一个 sockaddr_in 的结构体, 结构体如下:

```
struct sockaddr_in {  
    short    sin_family;  
    u_short  sin_port;  
    struct in_addr  sin_addr;
```




```
char    sin_zero[8];  
};
```

(1) 参数意义

sin_family 指代协议族，在 socket 编程中只能是 AF_INET

sin_port 存储端口号（使用网络字节顺序）

sin_addr 存储 IP 地址，使用 in_addr 这个数据结构

sin_zero 是为了让 sockaddr 与 sockaddr_in 两个数据结构保持大小相同而保留的空字节。

s_addr 按照网络字节顺序存储 IP 地址

(2) 例子

如 udpserve.c 文件中绑定前的设定：

```
my_socket.sin_family = AF_INET; // 可用网络的类型
```

```
my_socket.sin_port = htons(10000); // 选择端口号 10000
```

```
my_socket.sin_addr.s_addr = INADDR_ANY; // 接受 IP 地址，设置为任意地址
```

5. 说明面向连接的客户端和面向非连接的客户端在建立 Socket 时有什么区别。

答：用 socket 函数创建套接字时，对于面向连接的网络协议通讯时，type 指定为 SOCK_STREAM，这表示建立一个 socket 用于流式网络通讯；对于面向非连接的客户端，type 指定为 SOCK_DGRAM，它是无连接的，不可靠的。

6. 说明面向连接的客户端和面向非连接的客户端在收发数据时有什么区别。面向非连接的客户端又是如何判断数据发送结束的？

答：在面向非连接的 socket 程序中，在发送和接受数据时，会用到 write/send/sendto 和 read/recv/recvfrom，同时也会用 send/recv，但在发送数据时，如果用 sendto，就不用 connect；但在面向连接的 socket 程序中，发送数据时必须 connect。无论面向连接的客户端还是面向非连接的客户端，默认情况都是创建阻塞模式的套接字，执行到 connect, accept, write/send/sendto, read/recv/recvfrom 等语句时，会一直等待。

7. 比较面向连接的通信和无连接通信，他们各有什么有点和缺点？适合在哪种场合下使用？

答：面向连接通信

优点：非常可靠，万无一失，比如可靠体现在传递数据之前的三次握手来建立连接，而且数据传递时有确认、窗口、重传、拥塞控制机制。



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缺点：传输效率低，耗费资源多，每次建立连接和数据传递时的确认、重传等机制都会耗费大量时间。

面向非连接的通信：

优点：传输效率高，因为没有握手、确认等机制，是一个无状态的传输协议，所以传递数据非常快，同时攻击者可以利用的漏洞少一些。

缺点：不可靠，有丢失数据包、捣乱数据的风险，如果网络不好，容易丢包。

适用场合：

两种连接方式的特点决定了它们的应用场景，有些服务对可靠性要求比较高，必须数据包能够完整无误地送达，那就得选择有连接的套接字（TCP 服务），比如 HTTP、FTP 等；而另一些服务，并不需要那么高的可靠性，效率和实时才是它们所关心的，那就可以选择无连接的套接字（UDP 服务），比如 DNS、即时聊天工具等。

8. 实验过程中使用 Socket 时是工作在阻塞方式还是非阻塞方式？通过网络检索阐述这两种操作方式的不同

答：实验过程中使用 socket 时是工作在阻塞方式。阻塞调用是指调用结果返回之前，当前线程会被挂起。函数只有在得到结果之后才会返回。非阻塞指在不能立刻得到结果之前，该函数不会阻塞当前线程，而会立刻返回。

学号	学生	自评分
<u>18329015</u>	郝裕玮	<u>100</u>
<u>18325071</u>	张闯	<u>100</u>
<u>19335153</u>	马淙升	<u>100</u>