



哈尔滨工业大学
Harbin Institute of Technology

计算机网络 课程实验报告

实验名称	可靠数据传输协议					
姓名	石翔宇		院系	计算学部		
班级	1903103		学号	1190200523		
任课教师	刘亚维		指导教师	刘亚维		
实验地点	格物 207		实验时间	2021.11.07		
实验课表现	出勤、表现得分(10)		实验报告 得分(40)		实验总分	
	操作结果得分(50)					
教师评语						

实验目的：

理解可靠数据传输的基本原理；掌握停等协议的工作原理；掌握基于 UDP 设计并实现一个停等协议的过程与技术。

理解滑动窗口协议的基本原理；掌握 GBN 的工作原理；掌握基于 UDP 设计并实现一个 GBN 协议的过程与技术。

实验内容：

- 1) 基于 UDP 设计一个简单的停等协议，实现单向可靠数据传输（服务器到客户的数据传输）。
- 2) 模拟引入数据包的丢失，验证所设计协议的有效性。
- 3) 改进所设计的停等协议，支持双向数据传输；（选作内容，加分项目，可以当堂完成或课下完成）
- 4) 基于所设计的停等协议，实现一个 C/S 结构的文件传输应用。（选作内容，加分项目，可以当堂完成或课下完成）
- 5) 基于 UDP 设计一个简单的 GBN 协议，实现单向可靠数据传输（服务器到客户的数据传输）。
- 6) 模拟引入数据包的丢失，验证所设计协议的有效性。
- 7) 改进所设计的 GBN 协议，支持双向数据传输；（选作内容，加分项目，可以当堂完成或课下完成）
- 8) 将所设计的 GBN 协议改进为 SR 协议。（选作内容，加分项目，可以当堂完成或课下完成）

实验过程：
1. 实验要点：

- 1) 基于UDP实现的GBN协议，利用UDP协议差错检测；
- 2) 自行设计数据帧的格式，应至少包含序列号Seq和数据两部分；
- 3) 自行定义发送端序列号Seq比特数L以及发送窗口大小W，应满足条件 $W + 1 \leq 2^L$ 。
- 4) 一种简单的服务器端计时器的实现办法：设置套接字为非阻塞方式，则服务器端在recvfrom方法上不会阻塞，若正确接收到ACK消息，则计时器清零，若从客户端接收数据长度为-1（表示没有接收到任何数据），则计时器+1，对计时器进行判断，若其超过阈值，则判断为超时，进行超时重传。（当然，如果服务器选择阻塞模式，可以用到select或epoll的阻塞选择函数，详情见MSDN）
- 5) 为了模拟ACK丢失，一种简单的实现办法：客户端对接收的数据帧进行计数，然后对总数进行模N运算，若规定求模运算结果为零则返回ACK，则每接收N个数据帧才返回1个ACK。当N取值大于服务器端的超时阈值时，则会出现服务器端超时现象。
- 6) 当设置服务器端发送窗口的大小为1时，GBN协议就是停-等协议。

2. GBN协议/SR协议数据分组格式：

Seq	Data
-----	------

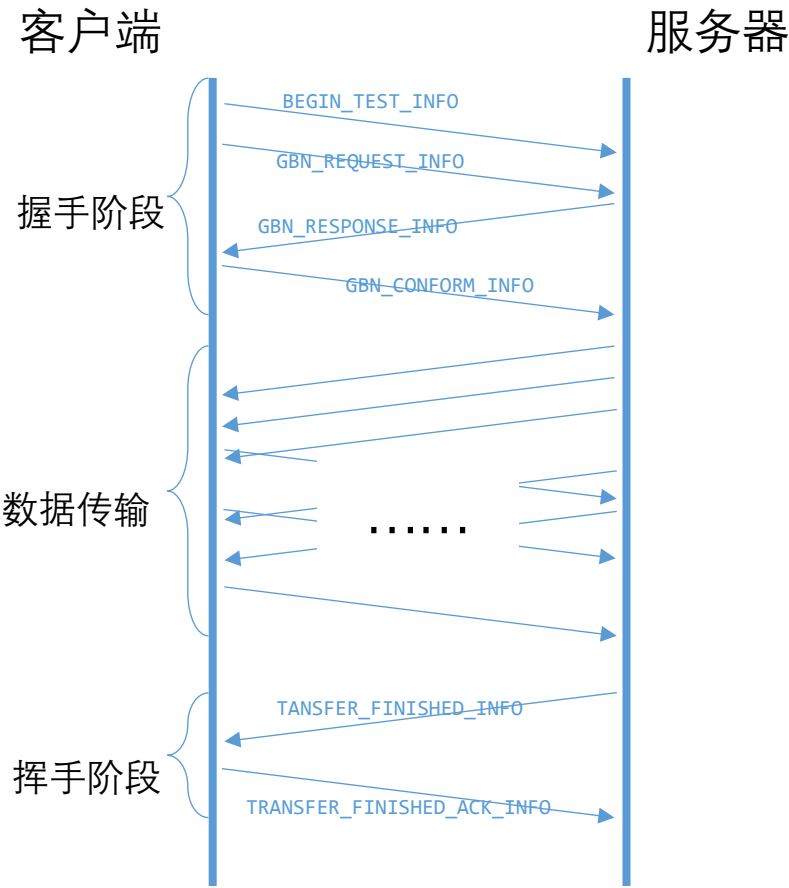
其中，Seq是数据分组的序列号，占1个字节，取值为0~255。Data是传输的数据内容，大小应小于1024个字节。

3. 确认分组格式：

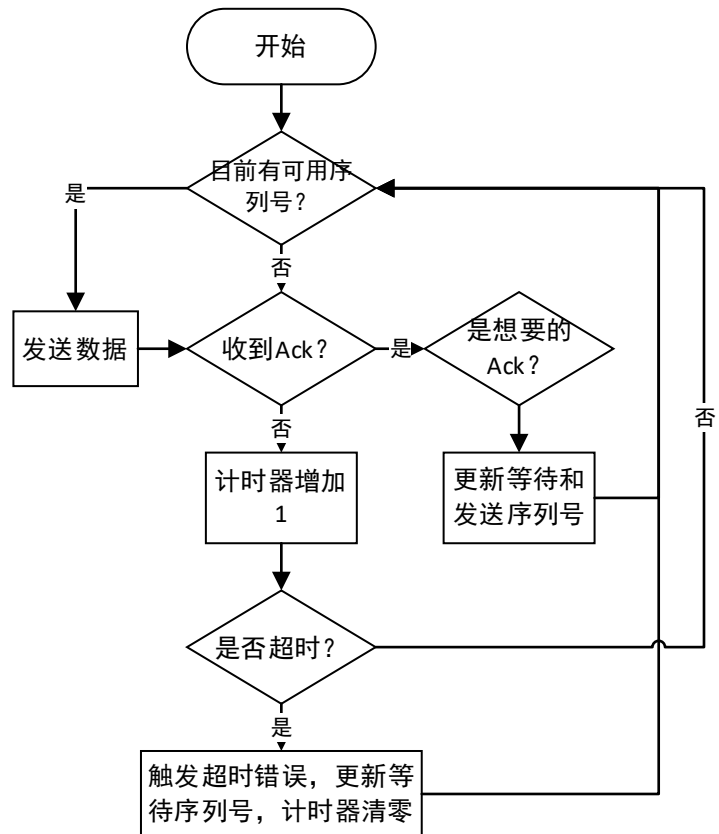
Ack

其中，Ack是确认数据分组的序列号，占1个字节，取值为 0~255。

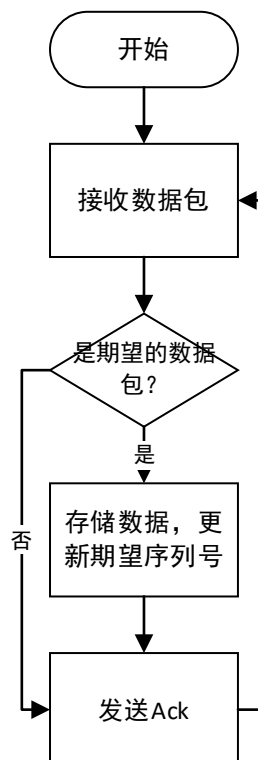
4. 协议典型交互过程：



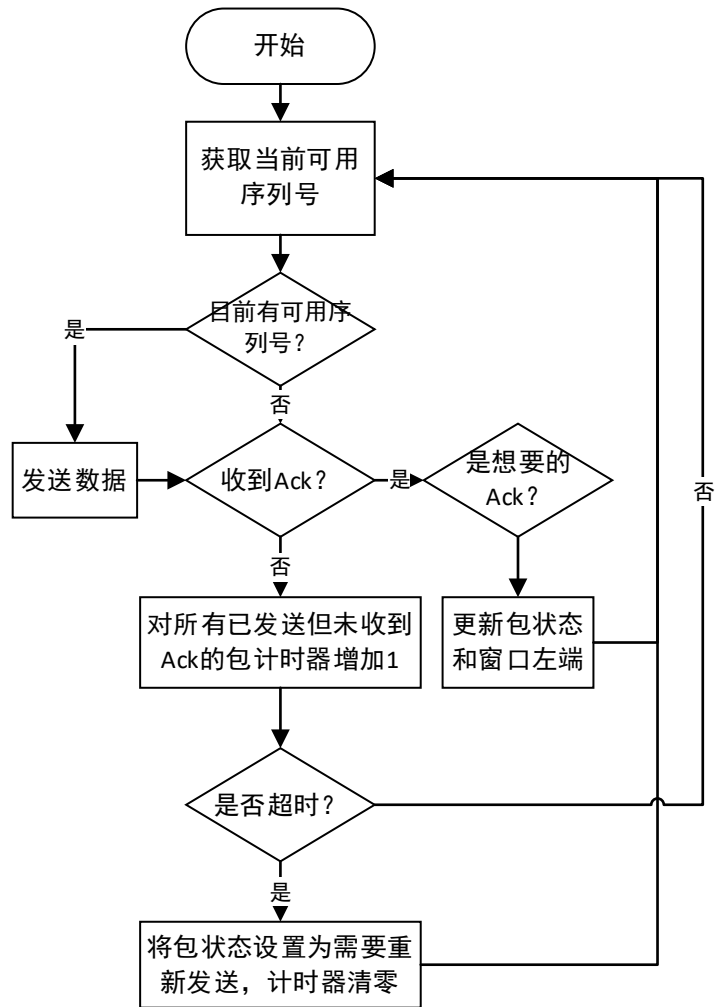
5. GBN协议数据发送端程序流程图：



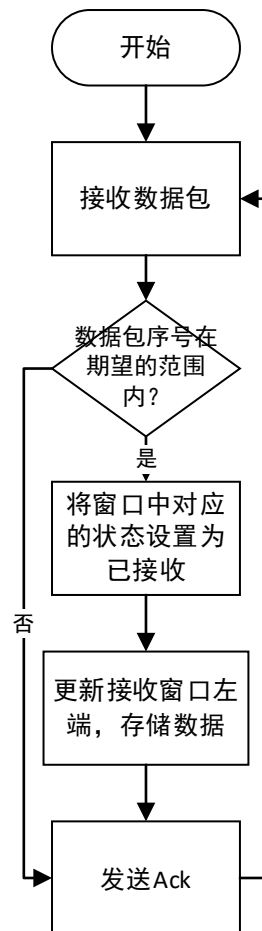
6. GBN协议数据接收端程序流程图:



7. SR协议数据发送端程序流程图:



8. SR协议数据接收端程序流程图:



9. 数据分组丢失验证模拟方法:

我们在数据接收端实现模拟数据分组丢失。对于接收到的数据分组，有一定概率（本实验中设置为20%）直接丢弃（模拟数据丢失）。Ack报文有一定概率（本实验中设置为20%）不发送（模拟Ack报文丢失）。

验证方式：我们将客户端收到的文件按序存储下来，传输完成后与原文件相比较，若无任何差异，则认为传输无错误。

实验结果:

1. 基于GBN协议的可靠数据传输:

服务器端:

```
(base) PS D:\Dedsecr\HIT-ComputerNetwork\lab\lab2> .\gbn_main.exe

*****
1. Test GBN as server
2. Test GBN as client
3. Quit
*****
1
There are 17 packets
Waiting for connection
receive from client: BEGIN_TEST_INFO
Begin testing GBN protocol, please don't abort the process
Shake hands stage
Receive request information from client
Begin transferring file using GBN
send a packet with a seq of 0
Receive an ack of 0
send a packet with a seq of 1
send a packet with a seq of 2
Receive an ack of 1
send a packet with a seq of 3
Receive an ack of 2
send a packet with a seq of 4
send a packet with a seq of 5
Receive an ack of 2
send a packet with a seq of 6
send a packet with a seq of 7
Receive an ack of 2
send a packet with a seq of 8
Receive an ack of 2
send a packet with a seq of 9
send a packet with a seq of 10
Receive an ack of 2
send a packet with a seq of 11
send a packet with a seq of 12
Receive an ack of 2
Receive an ack of 2
Timeout Error
send a packet with a seq of 3
Receive an ack of 3
send a packet with a seq of 4
send a packet with a seq of 5
Receive an ack of 4
send a packet with a seq of 6
Receive an ack of 5
send a packet with a seq of 7
send a packet with a seq of 8
Receive an ack of 6
send a packet with a seq of 9
send a packet with a seq of 10
Receive an ack of 7
send a packet with a seq of 11
Receive an ack of 8
send a packet with a seq of 12
send a packet with a seq of 13
Receive an ack of 9
send a packet with a seq of 14
Receive an ack of 9
send a packet with a seq of 15
send a packet with a seq of 16
Receive an ack of 9
Receive an ack of 9
Receive an ack of 9
Timeout Error
send a packet with a seq of 10
Receive an ack of 10
send a packet with a seq of 11
send a packet with a seq of 12
Receive an ack of 11
send a packet with a seq of 13
Receive an ack of 12
send a packet with a seq of 14
send a packet with a seq of 15
Receive an ack of 13
send a packet with a seq of 16
Receive an ack of 14
Timeout Error
send a packet with a seq of 15
Receive an ack of 15
send a packet with a seq of 16
Receive an ack of 16
Transfer finished
Transfer finished, sending information
Timeout, resending
Transfer end
```

客户端:

```
(base) PS D:\Dedsecr\HIT-ComputerNetwork\lab\lab2> .\gbn_main.exe

*****
1. Test GBN as server
2. Test GBN as client
3. Quit
*****
2
Begin testing GBN protocol
The loss ratio of packet is 0.10, the loss ratio of ack is 0.10
Receive response information from server
Ready for file transmission
receive a packet with a seq of 0
send a ack of 0
receive a packet with a seq of 1
send a ack of 1
receive a packet with a seq of 2
send a ack of 2
The packet with a seq of 3 loss
receive a packet with a seq of 4
The ack of 2 loss
receive a packet with a seq of 5
send a ack of 2
receive a packet with a seq of 6
send a ack of 2
receive a packet with a seq of 7
The ack of 2 loss
receive a packet with a seq of 8
send a ack of 2
receive a packet with a seq of 9
send a ack of 2
receive a packet with a seq of 10
send a ack of 2
receive a packet with a seq of 11
send a ack of 2
The packet with a seq of 12 loss
receive a packet with a seq of 3
send a ack of 3
receive a packet with a seq of 4
send a ack of 4
receive a packet with a seq of 5
send a ack of 5
receive a packet with a seq of 6
send a ack of 6
receive a packet with a seq of 7
send a ack of 7
receive a packet with a seq of 8
send a ack of 8
receive a packet with a seq of 9
send a ack of 9
The packet with a seq of 10 loss
receive a packet with a seq of 11
send a ack of 9
The packet with a seq of 12 loss
receive a packet with a seq of 13
send a ack of 9
receive a packet with a seq of 14
send a ack of 9
receive a packet with a seq of 15
send a ack of 9
receive a packet with a seq of 16
send a ack of 9
receive a packet with a seq of 10
send a ack of 10
receive a packet with a seq of 11
send a ack of 11
receive a packet with a seq of 12
send a ack of 12
receive a packet with a seq of 13
send a ack of 13
receive a packet with a seq of 14
The ack of 14 loss
The packet with a seq of 15 loss
receive a packet with a seq of 16
send a ack of 14
receive a packet with a seq of 15
send a ack of 15
receive a packet with a seq of 16
send a ack of 16
Receive transfer finished information from server
```

数据对比结果:

```
D:\Dedsecr\HIT-ComputerNetwork\lab\lab2>fc .\received_file_160620.txt .\bert.txt
正在比较文件 .\received_file_160620.txt 和 .\BERT.TXT
FC: 找不到差异
```


数据对比显示无错误。

2. 基于SR协议的可靠数据传输：

服务器端：

```
(base) PS D:\Dedsecr\HIT-ComputerNetwork\lab\lab2> .\sr_main.exe
*****
1. Test SR as server
2. Test SR as client
3. Quit
*****
1
There are 17 packets
Waiting for connection
receive from client: BEGIN_TEST_INFO
Begin testing GBN protocol, please don't abort the process
Shake hands stage
Receive request information from client
Begin transferring file using GBN
send a packet with a seq of 0
send a packet with a seq of 1
Receive an ack of 1
send a packet with a seq of 2
send a packet with a seq of 3
Receive an ack of 2
send a packet with a seq of 4
Receive an ack of 4
send a packet with a seq of 5
send a packet with a seq of 6
Receive an ack of 5
send a packet with a seq of 7
send a packet with a seq of 8
Receive an ack of 7
send a packet with a seq of 9
Receive an ack of 8
Receive an ack of 9
0 Timeout Error
send a packet with a seq of 0
3 Timeout Error
send a packet with a seq of 3
Receive an ack of 3
6 Timeout Error
send a packet with a seq of 6
Receive an ack of 6
0 Timeout Error
send a packet with a seq of 0
Receive an ack of 0
send a packet with a seq of 10
send a packet with a seq of 11
Receive an ack of 10
send a packet with a seq of 12
Receive an ack of 12
send a packet with a seq of 13
send a packet with a seq of 14
Receive an ack of 13
send a packet with a seq of 15
send a packet with a seq of 16
Receive an ack of 14
Receive an ack of 16
11 Timeout Error
send a packet with a seq of 11
15 Timeout Error
send a packet with a seq of 15
Receive an ack of 15
11 Timeout Error
send a packet with a seq of 11
Receive an ack of 11
Transfer finished
Transfer finished, sending information
Timeout, resending
Transfer end
```

客户端:

```
(base) PS D:\Dedsecr\HIT-ComputerNetwork\lab\lab2> .\sr_main.exe
*****
1. Test SR as server
2. Test SR as client
3. Quit
*****
2
Begin testing GBN protocol
The loss ratio of packet is 0.10, the loss ratio of ack is 0.10
Receive response information from server
Ready for file transmission
The packet with a seq of 0 loss
receive a packet with a seq of 1
send a ack of 1
receive a packet with a seq of 2
send a ack of 2
The packet with a seq of 3 loss
receive a packet with a seq of 4
send a ack of 4
receive a packet with a seq of 5
send a ack of 5
The packet with a seq of 6 loss
receive a packet with a seq of 7
send a ack of 7
receive a packet with a seq of 8
send a ack of 8
receive a packet with a seq of 9
send a ack of 9
The packet with a seq of 0 loss
receive a packet with a seq of 3
send a ack of 3
receive a packet with a seq of 6
send a ack of 6
receive a packet with a seq of 0
send a ack of 0
receive a packet with a seq of 10
send a ack of 10
receive a packet with a seq of 11
The ack of 11 loss
receive a packet with a seq of 12
send a ack of 12
receive a packet with a seq of 13
send a ack of 13
receive a packet with a seq of 14
send a ack of 14
The packet with a seq of 15 loss
receive a packet with a seq of 16
send a ack of 16
The packet with a seq of 11 loss
receive a packet with a seq of 15
send a ack of 15
receive a packet with a seq of 11
send a ack of 11
Receive transfer finished information from server
```

数据对比结果:

```
D:\Dedsecr\HIT-ComputerNetwork\lab\lab2>fc .\received_file_161110.txt .\bert.txt
正在比较文件 .\received_file_161110.txt 和 .\BERT.TXT
FC: 找不到差异
```

数据对比显示无错误。

问题讨论：

GBN协议和SR协议有哪些不同？

1. 接收缓冲区

对于GBN协议，由于它丢弃了接收端窗口内所有无序的数据包，所以不需要有一个缓冲区来存储接收端窗口内的无序数据包。

对于SR协议，由于避免了重传许多不必要的数据包，所以接收端需要对无序的数据包进行缓冲，其中窗口大小为N。

2. 实现的复杂性

GBN协议采用累积确认的方法。因为接收方是按顺序接收数据包的，所以任何错误到达的数据包都将被接收方丢弃。

SR协议避免了GBN协议以同时设置发送方窗口和接收方窗口大小相同为代价，重传到达接收方的正确数据包。

所以基本上，SR协议比GBN更复杂，因为SR协议的接收者需要一个缓冲区来确认是否正确地接收了包，不管它是否有序。

3. 网络效率

SR协议比GBN协议更有效。GBN协议中当窗口大小和带宽的乘积延迟很大，一个数据包在错误可能导致GBN重新发送大量的数据包；而在SR协议中，许多正确的数据包的顺序在这个过程中不需要重传。

心得体会：

通过此次实验，我对于可靠数据通信的认识有了提高，对 GBR 和 SR 协议的有了更加深刻的了解，也对滑动窗口这种机制有了更加切实的体会。SR利用滑动窗口这种机制可以有效地提高传输速率。