计算机网络课程报告

Reliable Data Transfer Protocol

RDT 实验报告

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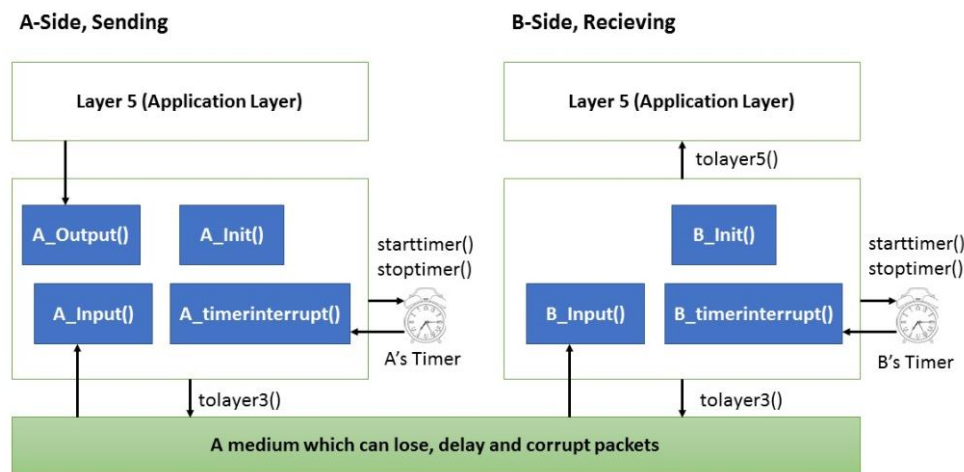学　　号 ___3019244266___

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一、实验内容概述

本次实验要求编写传输层代码，实现单向传输情景下的 Stop-and-Wait 和 Go-Back-N 两种协议。

实验已经提供了模拟仿真的基础结构，我们只需要补充并实现每个节点的传输层代码，具体包括节点传输层的初始化操作、节点接收到应用层消息的处理过程、节点接收到网络层数据包的处理过程、节点计时器到时的响应过程等内容。

二、实现过程

2.1 总体结构

2.2 已提供示例代码

在实验中，示例代码 prog.c 提供了输出界面的代码：

2.2.1 starttimer(calling_entity, increment)

参数中，calling_entity 设置为 0 时，用于启动 A 侧计数器；设置为 1 时，用于启动 B 侧计数器，increment 为浮点值，代表计数器中断之前经过的时间。A 侧的计时器只能由 A 侧启动或停止，B 侧同理。

2.2.2 stoptimer(calling_entity)

参数中，calling_entity 设置为 0 时，用于停止 A 侧计时器；设置为 1 时，用于停止 B 侧计时器。

2.2.3 tolayer3(calling_entity, packet)

参数中，calling_entity 设置为 0 时，用于 A 侧发送 packet；设置为 1 时，用于 B 侧发送 packet。Packet 为 struct pkt 结构。该函数用于将 packet 发送到其他 entity。

2.2.4 tolayer5(calling_entity, message)

参数中，calling_entity 设置为 0 时，用于将 A 侧的消息发送至应用层（第五层）；设置为 1 时，用于将 B 侧的消息发送到应用层。message 为 struct msg 结构。该函数用于将消息传递至应用层。

2.3 实验过程中需要实现的函数

2.3.1 A_output(message)

参数中，message 是 struct msg 结构，包含需要发送到 B 端的数据，每当发送方（A）有要发送的消息时，都会调用该函数。

$该协议实验的工作就是要确保消息中的数据可以按照顺序正确地传递到接收方。

2.3.2 B_output(message)

同 2.3.1，从 B 发送到 A。

2.3.3 A_input(packet)

参数中，packet 是 struct pkt 结构，每当从 B 一侧发送的数据包到达 A 侧时，都会调用此函数。

$由于我们只考虑到从 A 到 B 的单向数据传输，A_input 接收到的应该是 B 回传的确认包等内容。具体根据协议不同而改变。

2.3.4 B_input(packet)

同 2.3.3，从 A 发送的数据包到达 B 侧时，会调用此函数。

$数据包可能经过了延迟，甚至已经损坏。

2.3.5 A_timerinterrupt()

当 A 的计数器到期（导致计时器中断）时，会调用此函数。我们用于控制数据包的重传。

2.3.6 B_timerinterrupt()

同 2.3.5，（B 的计时器）

2.3.7 A_init()

在调用任何 A 侧的函数之前，需要执行必要的初始化。

2.3.8 B_init()

同 2.3.7（B 侧）

三、实现细节

3.1 Stop-and-Wait

对于停等协议来说：

发送方需要做到为每一个已发送但未被确认的分组都需要设置一个定时器,当定时器超时的时候只发送它对应的分组。当发送方收到 ACK 的时候，如果是窗口内的第一个分组,则窗口需要一直移动到已发送但未确认的分组序号。

对于接收方,需要设置一个窗口大小的缓存,即使是乱序到达的数据帧也进行缓存,并发送相应序号的 ACK, 并及时更新窗口的位置,窗口的更新原则同发送方。

3.2 Go-Back-N

GBN 协议的传送流程是:从上层应用层获得到一个完整的数据报,将这个数据报进行拆分，如果发送方的滑动窗口中,如果窗口内已经被发送但未收到确认的分组数目未达到窗口长度,就将窗口剩余的分组全部用来发送新构造好的数据,剩余未能发送的数据进行缓存。发送完窗口大小的数据分组后,开始等待接收从接收方发来的确定信息(ACK),GBN 协议采取了累积确认,当发送方收到一个对分组 n 的 ACK 的时候，即表明接方对于分组 n 以及分组 n 之前的分组全部都收到了。对于已经确认的分组,就将窗口滑动到未确认的分组位置(窗口又有空闲位置,可以发送剩余分组了),对于未确认的分组,如果计时器超时,就需要重新发送,直到收到接收方的 ACK 为止。

对于超时的触发，GBN 协议会将当前所有已发送但未被确认的分组重传，即如果当前窗口内都是已发送但未被确认的分组,一旦定时器发现窗口内的第一个分组超时,则窗口内所有分组都要被重传。每次当发送方收到一个 ACK 的时候，定时器都会被重置。

接收方只需要按序接收分组,对于比当前分组序号还要大的分组则直接丢弃。假设接收方正在等待接收分组 n，而分组 n+1 却已经到达了，于是，分组 n+1 被直接丢弃，所以发送方并不会出现在连续发送分组 n，分组 n+1 之后，而分组 n+1 的 ACK 却比分组 n 的 ACK 更早到达发送方的情况。

四、仿真过程

在运行文件的过程中，主函数中的 init()函数中有以下语句：

printf("-----　　Stop and Wait Network Simulator Version 1.1 -------- \n\n");

printf("Enter the number of messages to simulate: ");

scanf("%d",&nsimmax);

printf("Enter　　packet loss probability [enter 0.0 for no loss]:");

scanf("%f",&lossprob);

printf("Enter packet corruption probability [0.0 for no corruption]:");

scanf("%f",&corruptprob);

printf("Enter average time between messages from sender's layer5 [> 0.0]:");

scanf("%f",&lambda);

printf("Enter TRACE:");

scanf("%d",&TRACE);

在这五个分句中，我们分别需要输入五个参数，来模拟网络环境的情况：

（1）nsimmax：需要发送的消息数。

（2）lossprob：设定丢包概率。

（3）corruptprob：设定数据包被破坏的概率。

（4）lambda：设定来自发送方应用层的消息传输平均间隔时间(>0.0)，lambda 的值越小，发送得越快。

（5）TRACE：该参数表示输出消息的详细程度（输出消息的类型）。设置为 1 或 2 时会打印出相对简略但足以有价值的信息，例如数据包和记录时间等消息；而当设置为大于 2 的参数时，会输出更加详细的信息，例如"TOLAYER3:xxx"或"INSERTVENT:"等消息。

仿真的时候，我们可以分别对 SW.c 和 GBN.c 文件进行编译，并运行.exe 文件，分别设置变量 lossprob=0.25 和 corruptprob=0.2，进行结果分析。

五、仿真结果

5.1 Stop-and-Wait

5.1.1 发送 20 条消息，丢包概率为 0.0，损坏概率为 0.0，lambda=10，TRACE=2

（中间过于冗长，跳过）

5.1.2 发送 20 条消息，丢包概率为 0.25，损坏概率为 0，lambda=10，TRACE=2

```
EVENT time: 50.578938,   type: 1, fromlayer5  entity: 0
A: send seq:0, ack:0, msg:eeeeeeeeeeeeeeeeeeee

EVENT time: 56.140324,   type: 2, fromlayer3  entity: 1
B: rev seq:0, ack:0, msg:eeeeeeeeeeeeeeeeeeee
B: rev:0, looking for:0
B: send seq:0, ack:0, msg:ACK
        TOLAYER3: packet being lost

EVENT time: 57.463303,   type: 1, fromlayer5  entity: 0

EVENT time: 68.762474,   type: 1, fromlayer5  entity: 0

EVENT time: 70.578934,   type: 0, timerinterrupt    entity: 0
A: resend seq:0, ack:0, msg:eeeeeeeeeeeeeeeeeeee

EVENT time: 74.898552,   type: 2, fromlayer3  entity: 1
B: rev seq:0, ack:0, msg:eeeeeeeeeeeeeeeeeeee
B: rev:0, looking for:1
```

```
EVENT time: 207.166977,  type: 0, timerinterrupt    entity: 0
        TOLAYER3: packet being lost
A: resend seq:0, ack:0, msg:nnnnnnnnnnnnnnnnnnnn

EVENT time: 225.409729,  type: 1, fromlayer5  entity: 0

EVENT time: 227.166977,  type: 0, timerinterrupt    entity: 0
        TOLAYER3: packet being lost
A: resend seq:0, ack:0, msg:nnnnnnnnnnnnnnnnnnnn

EVENT time: 227.633911,  type: 1, fromlayer5  entity: 0

EVENT time: 229.888016,  type: 1, fromlayer5  entity: 0

EVENT time: 241.028488,  type: 1, fromlayer5  entity: 0
 Simulator terminated at time 241.028488
 after sending 20 msgs from layer5
```

5.1.3 发送 20 条消息，丢包概率为 0.0，损坏概率为 0.2，lambda=10，TRACE=2

```
Windows PowerShell
PS D:\Desktop\1895楼，一跃解千愁\20212\计算机网络\ReliableDataTransfer> ./SW.exe
----- Stop and Wait Network Simulator Version 1.1 --------

Enter the number of messages to simulate: 20
Enter  packet loss probability [enter 0.0 for no loss]:0
Enter packet corruption probability [0.0 for no corruption]:0.2
Enter average time between messages from sender's layer5 [ > 0.0]:10
Enter TRACE:2

EVENT time: 0.935697,   type: 1, fromlayer5  entity: 0
A: send seq:0, ack:0, msg:aaaaaaaaaaaaaaaaaaaa

EVENT time: 6.428144,   type: 2, fromlayer3  entity: 1
B: rev seq:0, ack:0, msg:aaaaaaaaaaaaaaaaaaaa
B: rev:0, looking for:0
B: send seq:0, ack:0, msg:ACK
```

```
EVENT time: 105.697502,  type: 2, fromlayer3  entity: 0
A: rev scknum:0, looking for:0
ACK.

EVENT time: 107.851196,  type: 1, fromlayer5  entity: 0
        TOLAYER3: packet being corrupted
A: send seq:1, ack:0, msg:jjjjjjjjjjjjjjjjjjjj

EVENT time: 112.589958,  type: 2, fromlayer3  entity: 1
B: rev seq:1, ack:0, msg:Zjjjjjjjjjjjjjjjjjjj
B: rev:1, looking for:1
B: send seq:0, ack:1, msg:NAK

EVENT time: 114.394730,  type: 2, fromlayer3  entity: 0
A: rev scknum:1, looking for:1
NAK.
Warning: attempt to start a timer that is already started

EVENT time: 118.041939,  type: 1, fromlayer5  entity: 0
```

```
EVENT time: 188.711075,   type: 2, fromlayer3   entity: 0
A: rev scknum:1, looking for:1
ACK.

EVENT time: 190.824326,   type: 1, fromlayer5   entity: 0
        TOLAYER3: packet being corrupted
A: send seq:0, ack:0, msg:tttttttttttttttttttt

EVENT time: 197.193237,   type: 2, fromlayer3   entity: 1
 Simulator terminated at time 197.193237
 after sending 20 msgs from layer5
```

5.2.4 发送 20 条消息，丢包概率为 0.25，损坏概率为 0.2，lambda=10，TRACE=2

```
Windows PowerShell
PS D:\Desktop\1895楼，一跃解千愁\20212\计算机网络\ReliableDataTransfer> ./SW.exe
-----  Stop and Wait Network Simulator Version 1.1 --------

Enter the number of messages to simulate: 20
Enter  packet loss probability [enter 0.0 for no loss]:0.25
Enter packet corruption probability [0.0 for no corruption]:0.2
Enter average time between messages from sender's layer5 [ > 0.0]:10
Enter TRACE:2

EVENT time: 0.935697,   type: 1, fromlayer5   entity: 0
A: send seq:0, ack:0, msg:aaaaaaaaaaaaaaaaaaaa

EVENT time: 6.428144,   type: 2, fromlayer3   entity: 1
B: rev seq:0, ack:0, msg:aaaaaaaaaaaaaaaaaaaa
B: rev:0, looking for:0
B: send seq:0, ack:0, msg:ACK
```

```
EVENT time: 45.933746,   type: 2, fromlayer3   entity: 0
A: rev scknum:1, looking for:1
ACK.

EVENT time: 50.578938,   type: 1, fromlayer5   entity: 0
A: send seq:0, ack:0, msg:eeeeeeeeeeeeeeeeeeee

EVENT time: 56.140324,   type: 2, fromlayer3   entity: 1
B: rev seq:0, ack:0, msg:eeeeeeeeeeeeeeeeeeee
B: rev:0, looking for:0
B: send seq:0, ack:0, msg:ACK
        TOLAYER3: packet being lost

EVENT time: 57.463303,   type: 1, fromlayer5   entity: 0

EVENT time: 68.762474,   type: 1, fromlayer5   entity: 0

EVENT time: 70.578934,   type: 0, timerinterrupt   entity: 0
        TOLAYER3: packet being corrupted
A: resend seq:0, ack:0, msg:eeeeeeeeeeeeeeeeeeee

EVENT time: 74.898552,   type: 2, fromlayer3   entity: 1
B: rev seq:0, ack:0, msg:Zeeeeeeeeeeeeeeeeeeee
B: rev:0, looking for:1
        TOLAYER3: packet being lost
B: send seq:0, ack:0, msg:ACK
```

```
EVENT time: 213.705261,   type: 1, fromlayer5   entity: 0

EVENT time: 228.951691,   type: 1, fromlayer5   entity: 0

EVENT time: 229.650574,   type: 0, timerinterrupt   entity: 0
        TOLAYER3: packet being lost
A: resend seq:0, ack:0, msg:pppppppppppppppppppp

EVENT time: 247.893311,   type: 1, fromlayer5   entity: 0

EVENT time: 249.650574,   type: 0, timerinterrupt   entity: 0
 Simulator terminated at time 249.650574
 after sending 20 msgs from layer5
```

5.2 Go-Back-N

5.2.1 发送 20 条消息，丢包概率为 0.0，损坏概率为 0.0，lambda=10，TRACE=2


```
PS D:\Desktop\1895楼，一跃解千愁\20212\计算机网络\ReliableDataTransfer> ./GBN.exe
----- Stop and Wait Network Simulator Version 1.1 --------

Enter the number of messages to simulate: 20
Enter  packet loss probability [enter 0.0 for no loss]:0
Enter packet corruption probability [0.0 for no corruption]:0
Enter average time between messages from sender's layer5 [ > 0.0]:10
Enter TRACE:2

EVENT time: 0.935697,  type: 1, fromlayer5  entity: 0
A: send seq:407, ack:479, msg:aaaaaaaaaaaaaaaaaaaa

EVENT time: 1.941191,  type: 2, fromlayer3  entity: 1
B: rev seq:407, ack:479, msg:aaaaaaaaaaaaaaaaaaaa
B: rev:407, looking for:407
B: send seq:479, ack:408, msg:ACK
```

```
EVENT time: 178.786591,  type: 1, fromlayer5  entity: 0
A: send seq:425, ack:497, msg:sssssssssssssssssss

EVENT time: 179.084335,  type: 2, fromlayer3  entity: 1
B: rev seq:419, ack:491, msg:mmmmmmmmmmmmmmmmmmmm
B: rev:419, looking for:424
B: send seq:491, ack:420, msg:ACK

EVENT time: 181.439255,  type: 1, fromlayer5  entity: 0
A: send seq:426, ack:498, msg:tttttttttttttttttttt

EVENT time: 183.617096,  type: 2, fromlayer3  entity: 1
 Simulator terminated at time 183.617096
 after sending 20 msgs from layer5
```

5.2.2 发送 20 条消息，丢包概率为 0.25，损坏概率为 0.0，lambda=10，TRACE=2


```
PS D:\Desktop\1895楼，一跃解千愁\20212\计算机网络\ReliableDataTransfer> ./GBN.exe
----- Stop and Wait Network Simulator Version 1.1 --------

Enter the number of messages to simulate: 20
Enter  packet loss probability [enter 0.0 for no loss]:0.25
Enter packet corruption probability [0.0 for no corruption]:0.0
Enter average time between messages from sender's layer5 [ > 0.0]:10
Enter TRACE:2

EVENT time: 0.935697,  type: 1, fromlayer5  entity: 0
A: send seq:407, ack:479, msg:aaaaaaaaaaaaaaaaaaaa

EVENT time: 1.941191,  type: 2, fromlayer3  entity: 1
B: rev seq:407, ack:479, msg:aaaaaaaaaaaaaaaaaaaa
B: rev:407, looking for:407
B: send seq:479, ack:408, msg:ACK
```

```
EVENT time: 64.252846,  type: 2, fromlayer3  entity: 1
B: rev seq:413, ack:485, msg:gggggggggggggggggggg
B: rev:413, looking for:413
B: send seq:485, ack:414, msg:ACK

EVENT time: 65.600021,  type: 2, fromlayer3  entity: 1
B: rev seq:414, ack:486, msg:hhhhhhhhhhhhhhhhhhhh
B: rev:414, looking for:414
B: send seq:486, ack:415, msg:ACK
        TOLAYER3: packet being lost

EVENT time: 65.780815,  type: 1, fromlayer5  entity: 0
A: send seq:415, ack:487, msg:iiiiiiiiiiiiiiiiiiii
```

```
EVENT time: 190.172714,  type: 2, fromlayer3  entity: 0
A: rev ack:494, looking for:494
ACK.

EVENT time: 193.462936,  type: 1, fromlayer5  entity: 0
A: send seq:426, ack:498, msg:tttttttttttttttttttt

EVENT time: 198.673309,  type: 2, fromlayer3  entity: 0
 Simulator terminated at time 198.673309
 after sending 20 msgs from layer5
```

5.2.3 发送 20 条消息，丢包概率为 0.0，损坏概率为 0.2，lambda=10，TRACE=2

```
Windows PowerShell
PS D:\Desktop\1895楼，一跃解千愁\20212\计算机网络\ReliableDataTransfer> ./GBN.exe
-----  Stop and Wait Network Simulator Version 1.1 --------

Enter the number of messages to simulate: 20
Enter  packet loss probability [enter 0.0 for no loss]:0
Enter packet corruption probability [0.0 for no corruption]:0.2
Enter average time between messages from sender's layer5 [ > 0.0]:10
Enter TRACE:2

EVENT time: 0.935697,  type: 1, fromlayer5  entity: 0
A: send seq:407, ack:479, msg:aaaaaaaaaaaaaaaaaaaa

EVENT time: 1.941191,  type: 2, fromlayer3  entity: 1
B: rev seq:407, ack:479, msg:aaaaaaaaaaaaaaaaaaaa
B: rev:407, looking for:407
B: send seq:479, ack:408, msg:ACK

EVENT time: 4.944609,  type: 2, fromlayer3  entity: 0
A: rev ack:479, looking for:479
ACK.

EVENT time: 52.164646,  type: 2, fromlayer3  entity: 1
B: rev seq:411, ack:483, msg:eeeeeeeeeeeeeeeeeeee
B: rev:411, looking for:411
B: send seq:483, ack:412, msg:ACK
         TOLAYER3: packet being corrupted

EVENT time: 54.072239,  type: 2, fromlayer3  entity: 0
A: rev ack:482, looking for:483

EVENT time: 54.650105,  type: 1, fromlayer5  entity: 0
A: send seq:412, ack:484, msg:ffffffffffffffffffff

EVENT time: 56.823479,  type: 2, fromlayer3  entity: 1
B: rev seq:412, ack:484, msg:ffffffffffffffffffff
B: rev:412, looking for:412
B: send seq:484, ack:413, msg:ACK

EVENT time: 59.461746,  type: 0, timerinterrupt   entity: 0
A: send seq:411, ack:483, msg:eeeeeeeeeeeeeeeeeeee
A: send seq:412, ack:484, msg:ffffffffffffffffffff

EVENT time: 62.630241,  type: 2, fromlayer3  entity: 0
A: rev ack:482, looking for:483

EVENT time: 65.233467,  type: 2, fromlayer3  entity: 0
A: rev ack:483, looking for:483
Corrupted.

EVENT time: 65.578781,  type: 2, fromlayer3  entity: 1
B: rev seq:411, ack:483, msg:eeeeeeeeeeeeeeeeeeee
B: rev:411, looking for:413
B: send seq:483, ack:412, msg:ACK
```

```
EVENT time: 215.068634,   type: 2, fromlayer3   entity: 1
B: rev seq:420, ack:492, msg:nnnnnnnnnnnnnnnnnnnn
B: rev:420, looking for:420
B: send seq:492, ack:421, msg:ACK

EVENT time: 216.721954,   type: 2, fromlayer3   entity: 0
A: rev ack:489, looking for:487

EVENT time: 221.700394,   type: 2, fromlayer3   entity: 1
B: rev seq:413, ack:485, msg:gggggggggggggggggggg
B: rev:413, looking for:421
B: send seq:485, ack:414, msg:ACK

EVENT time: 221.888763,   type: 0, timerinterrupt    entity: 0
A: send seq:415, ack:487, msg:iiiiiiiiiiiiiiiiiiii
A: send seq:416, ack:488, msg:jjjjjjjjjjjjjjjjjjjj
A: send seq:417, ack:489, msg:kkkkkkkkkkkkkkkkkkkk
        TOLAYER3: packet being corrupted
A: send seq:418, ack:490, msg:llllllllllllllllllll
        TOLAYER3: packet being corrupted
A: send seq:419, ack:491, msg:mmmmmmmmmmmmmmmmmmmm
A: send seq:420, ack:492, msg:nnnnnnnnnnnnnnnnnnnn
A: send seq:421, ack:493, msg:oooooooooooooooooooo
A: send seq:422, ack:494, msg:pppppppppppppppppppp

EVENT time: 223.249893,   type: 2, fromlayer3   entity: 0
A: rev ack:490, looking for:487

EVENT time: 224.079102,   type: 1, fromlayer5   entity: 0

EVENT time: 225.941345,   type: 1, fromlayer5   entity: 0
 Simulator terminated at time 225.941345
 after sending 20 msgs from layer5
PS D:\Desktop\1895楼，一跃解千愁\20212\计算机网络\ReliableDataTransfer>
```

5.2.4 发送 20 条消息，丢包概率为 0.25，损坏概率为 0.2，lambda=10，TRACE=2

```
Windows PowerShell
PS D:\Desktop\1895楼，一跃解千愁\20212\计算机网络\ReliableDataTransfer> ./GBN.exe
-----  Stop and Wait Network Simulator Version 1.1 --------

Enter the number of messages to simulate: 20
Enter  packet loss probability [enter 0.0 for no loss]:0.25
Enter packet corruption probability [0.0 for no corruption]:0.2
Enter average time between messages from sender's layer5 [ > 0.0]:10
Enter TRACE:2

EVENT time: 0.935697,   type: 1, fromlayer5   entity: 0
A: send seq:407, ack:479, msg:aaaaaaaaaaaaaaaaaaaa
```

```
EVENT time: 148.286438,   type: 2, fromlayer3   entity: 1
B: rev seq:411, ack:483, msg:eeeeeeeeeeeeeeeeeeeee
B: rev:411, looking for:417
        TOLAYER3: packet being corrupted
B: send seq:483, ack:412, msg:ACK

EVENT time: 148.286987,   type: 2, fromlayer3   entity: 0
A: rev ack:488, looking for:487

EVENT time: 148.898590,   type: 1, fromlayer5   entity: 0
A: send seq:421, ack:493, msg:ooooooooooooooooooooo

EVENT time: 151.818588,   type: 2, fromlayer3   entity: 1
B: rev seq:412, ack:484, msg:fffffffffffffffffffff
B: rev:412, looking for:417
B: send seq:484, ack:413, msg:ACK

EVENT time: 154.388977,   type: 0, timerinterrupt     entity: 0
        TOLAYER3: packet being lost
A: send seq:415, ack:487, msg:iiiiiiiiiiiiiiiiiiiii
        TOLAYER3: packet being corrupted
A: send seq:416, ack:488, msg:jjjjjjjjjjjjjjjjjjjjj
A: send seq:417, ack:489, msg:kkkkkkkkkkkkkkkkkkkkk
A: send seq:418, ack:490, msg:lllllllllllllllllllll
        TOLAYER3: packet being corrupted
A: send seq:419, ack:491, msg:mmmmmmmmmmmmmmmmmmmmm
A: send seq:420, ack:492, msg:nnnnnnnnnnnnnnnnnnnnn
A: send seq:421, ack:493, msg:ooooooooooooooooooooo

EVENT time: 156.787582,   type: 2, fromlayer3   entity: 0
A: rev ack:483, looking for:487

EVENT time: 161.364838,   type: 2, fromlayer3   entity: 1
B: rev seq:413, ack:485, msg:ggggggggggggggggggggg
B: rev:413, looking for:417
B: send seq:485, ack:414, msg:ACK
```

```
EVENT time: 198.350861,   type: 0, timerinterrupt     entity: 0
        TOLAYER3: packet being lost
A: send seq:416, ack:488, msg:jjjjjjjjjjjjjjjjjjjjj
A: send seq:417, ack:489, msg:kkkkkkkkkkkkkkkkkkkkk
A: send seq:418, ack:490, msg:lllllllllllllllllllll
A: send seq:419, ack:491, msg:mmmmmmmmmmmmmmmmmmmmm
A: send seq:420, ack:492, msg:nnnnnnnnnnnnnnnnnnnnn
        TOLAYER3: packet being lost
A: send seq:421, ack:493, msg:ooooooooooooooooooooo
        TOLAYER3: packet being lost
A: send seq:422, ack:494, msg:ppppppppppppppppppppp
A: send seq:423, ack:495, msg:qqqqqqqqqqqqqqqqqqqqq

EVENT time: 201.659042,   type: 2, fromlayer3   entity: 1
B: rev seq:416, ack:488, msg:Zjjjjjjjjjjjjjjjjjjjj
B: send seq:489, ack:418, msg:NAK

EVENT time: 204.274628,   type: 2, fromlayer3   entity: 1
B: rev seq:417, ack:489, msg:kkkkkkkkkkkkkkkkkkkkk
B: rev:417, looking for:418
B: send seq:489, ack:418, msg:ACK

EVENT time: 204.867813,   type: 2, fromlayer3   entity: 0
A: rev ack:489, looking for:488

EVENT time: 206.354568,   type: 1, fromlayer5   entity: 0

EVENT time: 212.304718,   type: 2, fromlayer3   entity: 1
 Simulator terminated at time 212.304718
 after sending 20 msgs from layer5
```

六、总结

  通过本次实验，我了解并顺利实现了 Stop-and-Wait 与 Go-Back-N 两种可靠数据传输协议的相关实验。回顾此次 RDT 代码的编写，我从理论到实践，学到了很多，不仅巩固了以前学到的理论知识，而且学以致用，将其运用在实践中。从理论中进行实践并获得实质成果，才能真正掌握这门技术，提高自己独立思考的能力。未来我会不断提高自己的理论和实践能力，并对实验进行改进与完善，提升自己在计算机网络方面的理论知识和实践能力。

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  通过本次实验，我了解并顺利实现了 Stop-and-Wait 与 Go-Back-N 两种可靠数据传输协议的相关实验。回顾此次 RDT 代码的编写，我从理论到实践，学到了很多，不仅巩固了以前学到的理论知识，而且学以致用，将其运用在实践中。从理论中进行实践并获得实质成果，才能真正掌握这门技术，提高自己独立思考的能力。未来我会不断提高自己的理论和实践能力，并对实验进行改进与完善，提升自己在计算机网络方面的理论知识和实践能力。