

RDT: Implementing a Reliable Transport Protocol

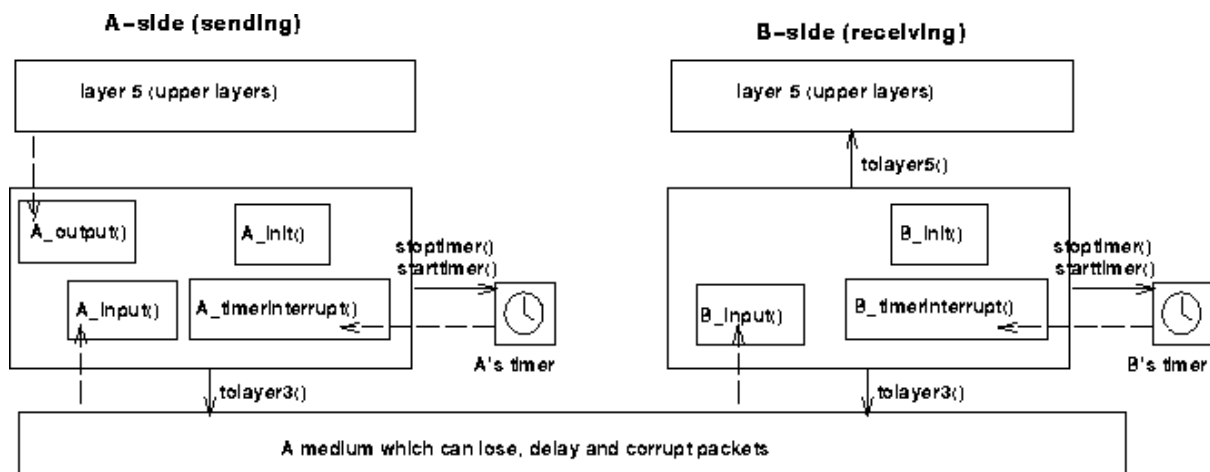
Overview

In this laboratory programming assignment, you will be writing the sending and receiving transport-level code for implementing a simple reliable data transfer protocol.

Since you probably don't have standalone machines (with an OS that you can modify), your code will have to execute in a simulated hardware/software environment. However, the programming interface provided to your routines, i.e., the code that would call your entities from above and from below is very close to what is done in an actual UNIX environment. (Indeed, the software interfaces described in this programming assignment are much more realistic than the infinite loop senders and receivers that many texts describe). Stopping/starting of timers are also simulated, and timer interrupts will cause your timer handling routine to be activated.

The routines you will write

The procedures you will write are for the sending entity (A) and the receiving entity (B). Only unidirectional transfer of data (from A to B) is required. Of course, the B side will have to send packets to A to acknowledge (positively or negatively) receipt of data. Your routines are to be implemented in the form of the procedures described below. These procedures will be called by (and will call) procedures that I have written which emulate a network environment. The overall structure of the environment is shown in the image below:



The unit of data passed between the upper layers and your protocols is a *message*, which is declared as:

```
class Msg:
    MSG_SIZE = 20

    def __init__(self, data):
        self.data = data

    def __str__(self):
        return 'Msg(data=%s)' % (self.data)
```

This declaration, and all other classes and emulator routines, as well as stub routines (i.e., those you are to complete) are in the file, **rdtsim_python**, described later. Your sending entity will thus receive data in 20-byte chunks from layer5; your receiving entity should deliver 20-byte chunks of correctly received data to layer5 at the receiving side.

The unit of data passed between your routines and the network layer is the *packet*, which is declared as:

```
class Pkt:
    def __init__(self, seqnum, acknum, checksum, payload):
        self.seqnum = seqnum
        self.acknum = acknum
        self.checksum = checksum
        self.payload = payload
        self.ack_is_lost = False
        self.pkt_is_lost = False

    def __str__(self):
        return ('Pkt(seqnum=%s, acknum=%s, checksum=%s, payload=%s)'
                % (self.seqnum, self.acknum, self.checksum, self.payload))
```

Your routines will fill in the payload field from the message data passed down from layer5. The other packet fields will be used by your protocols to insure reliable delivery, as we've seen in class.

The routines you will write are detailed below. As noted above, such procedures in real-life would be part of the operating system, and would be called by other procedures in the operating system.

- **A_output(message)**, where message is an instance of class Msg, containing data to be sent to the B-side. This routine will be called whenever the upper layer at the sending side (A) has a message to send. It is the job of your protocol to insure that the data in such a message is delivered in-order, and correctly, to the receiving side upper layer.
- **A_input(packet)**, where packet is an instance of class Pkt. This routine will be called whenever a packet sent from the B-side (i.e., as a result of a to_layer3() being done by a B-side procedure) arrives at the A-side. packet is the (possibly corrupted) packet sent from the B-side.
- **A_timer_interrupt()** This routine will be called when A's timer expires (thus generating a timer interrupt). You'll probably want to use this routine to control the retransmission of packets. See start_timer() and stop_timer() below for how the timer is started and stopped.
- **A_init()** This routine will be called once, before any of your other A-side routines are called. It can be used to do any required initialization.
- **B_input(packet)**, where packet is an instance of class Pkt. This routine will be called whenever a packet sent from the A-side (i.e., as a result of a to_layer3() being done by a A-side procedure) arrives at the B-side. packet is the (possibly corrupted) packet sent from the A-side.
- **B_init()** This routine will be called once, before any of your other B-side routines are called. It can be used to do any required initialization.

Software Interfaces

The procedures described above are the ones that you will write. I have written the following routines which can be called by your routines:

- **start_timer(calling_entity,increment)**, where calling_entity is either 0 (for starting the A-side timer) or 1 (for starting the B side timer), and increment is a *float* value indicating the amount of time that will pass before the timer interrupts. A's timer should only be started (or stopped) by A-side routines, and similarly for the B-side timer. To give you an idea of the appropriate increment value to use: a packet sent into the network takes an average of 5 time units to arrive at the other side when there are no other messages in the medium.
- **stop_timer(calling_entity)**, where calling_entity is either 0 (for stopping the A-side timer) or 1 (for stopping the B side timer).
- **to_layer3(calling_entity,packet)**, where calling_entity is either 0 (for the A-side send) or 1 (for the B side send), and packet is an instance of class Pkt. Calling this routine will cause the packet to be sent into the network, destined for the other entity.
- **to_layer5(calling_entity,message)**, where calling_entity is either 0 (for A-side delivery to layer 5) or 1 (for B-side delivery to layer 5), and message is an instance of class msg. With unidirectional data transfer, you would only be calling this with calling_entity equal to 1 (delivery to the B-side). Calling this routine will cause data to be passed up to layer 5.

The simulated network environment

A call to procedure tolayer3() sends packets into the medium (i.e., into the network layer). Your procedures A_input() and B_input() are called when a packet is to be delivered from the medium to your protocol layer.

The medium is capable of corrupting and losing packets. It will not reorder packets. When you compile your procedures and my procedures together and run the resulting program, you will be asked to specify values regarding the simulated network environment:

- **Number of messages to simulate.** My emulator (and your routines) will stop as soon as this number of messages have been passed down from layer 5, regardless of whether or not all of the messages have been correctly delivered. Thus, you need **not** worry about undelivered or unACK'ed messages still in your sender when the emulator stops. Note that if you set this value to 1, your program will terminate immediately, before the message is delivered to the other side. Thus, this value should always be greater than 1.
- **Loss.** You are asked to specify a packet loss probability. A value of 0.1 would mean that one in ten packets (on average) are lost.
- **Corruption.** You are asked to specify a packet loss probability. A value of 0.2 would mean that one in five packets (on average) are corrupted. Note that the contents of payload, sequence, ack, or checksum fields can be corrupted. Your checksum should thus include the data, sequence, and ack fields.
- **Tracing.** Setting a tracing value of 1 or 2 will print out useful information about what is going on inside the emulation (e.g., what's happening to packets and timers). A tracing value of 0 will turn this off. A tracing value greater than 2 will display all sorts of odd messages that are for my own emulator-debugging purposes. A tracing value of 2 may be helpful to you in debugging your code. You should keep in mind that *real* implementors do not have underlying networks that provide such nice information about what is going to happen to their packets!
- **Average time between messages from sender's layer5.** You can set this value to any non-zero, positive value. Note that the smaller the value you choose, the faster packets will be arriving to your sender.

The Go-Back-N version of this lab.

You are to write the procedures, `A_output()`, `A_input()`, `A_timerinterrupt()`, `A_init()`, `B_input()`, and `B_init()` which together will implement a Go-Back-N unidirectional transfer of data from the A-side to the B-side, with a window size of 8. Your protocol should use both ACK and NACK messages.

Some important details for your Go-Back-N code:

- **A_output(message)**, where message is an instance of class msg, containing data to be sent to the B-side.
Your `A_output()` routine will now sometimes be called when there are outstanding, unacknowledged messages in the medium - implying that you will have to buffer multiple messages in your sender. Also, you'll also need buffering in your sender because of the nature of Go-Back-N: sometimes your sender will be called but it won't be able to send the new message because the new message falls outside of the window.
Rather than have you worry about buffering an arbitrary number of messages, it will be OK for you to have some finite, maximum number of buffers available at your sender (say for 50 messages) and have your sender simply abort (give up and exit) should all 50 buffers be in use at one point (Note: using the values given below, this should never happen!) In the "real-world," of course, one would have to come up with a more elegant solution to the finite buffer problem!
- **A_timer_interrupt()** This routine will be called when A's timer expires (thus generating a timer interrupt). Remember that you've only got one timer, and may have many outstanding, unacknowledged packets in the medium, so you'll have to think a bit about how to use this single timer.

Helpful Hints and the like

- **Checksumming.** You can use whatever approach for checksumming you want. Remember that the sequence number and ack field can also be corrupted. We would suggest a TCP-like checksum, which consists of the sum of the (integer) sequence and ack field values, added to a character-by-character sum of the payload field of the packet (i.e., treat each character as if it were an 8 bit integer and just add them together).
- **START SIMPLE.** Set the probabilities of loss and corruption to zero and test out your routines. Better yet, design and implement your procedures for the case of no loss and no corruption, and get them working first. Then handle the case of one of these probabilities being non-zero, and then finally both being non-zero.
- **Debugging.** We'd recommend that you set the tracing level to 2 and put LOTS of printf's in your code while your debugging your procedures.
- **Random Numbers.** There is a random seed argument (-s) so that students can get repeatable results.