Homework 2: Lower Network Layers

Muyuan Zhang

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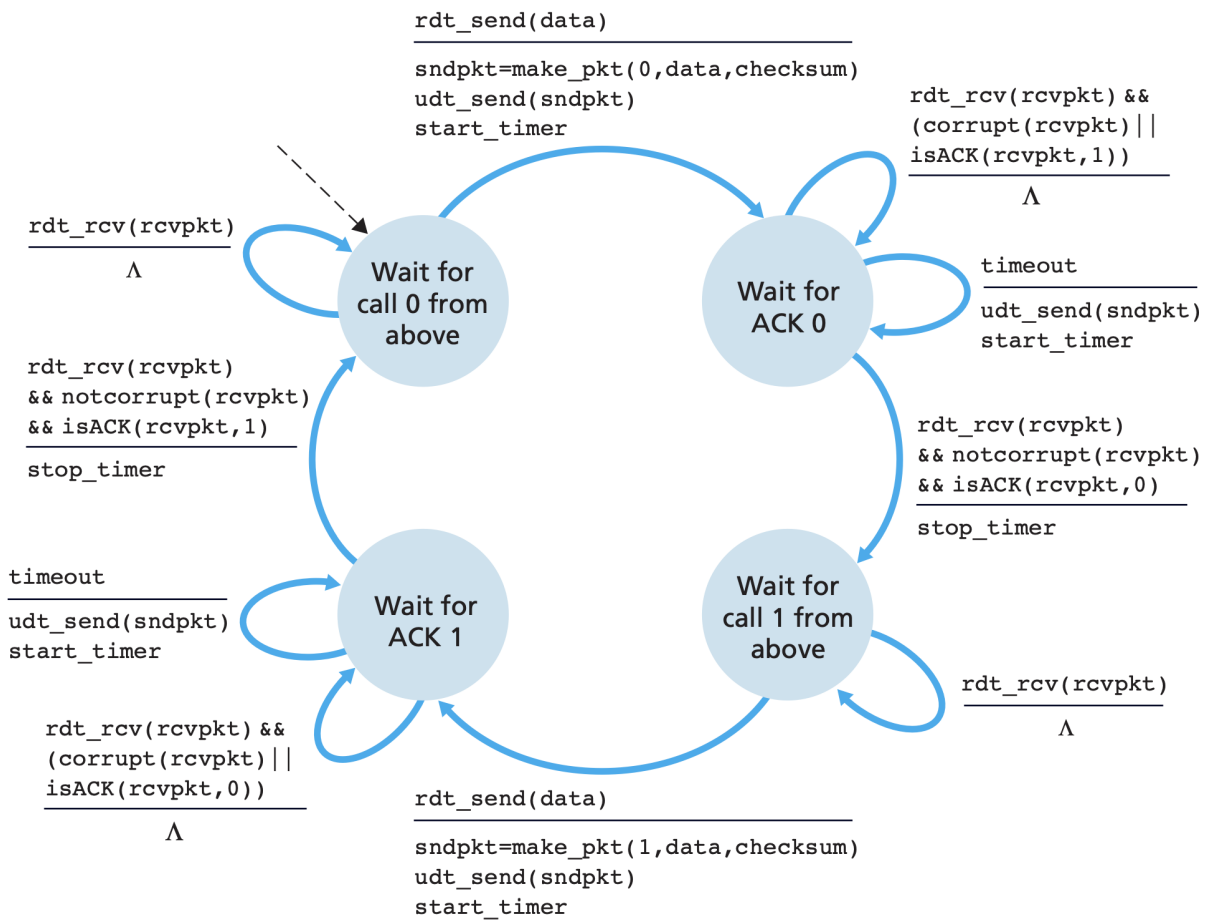
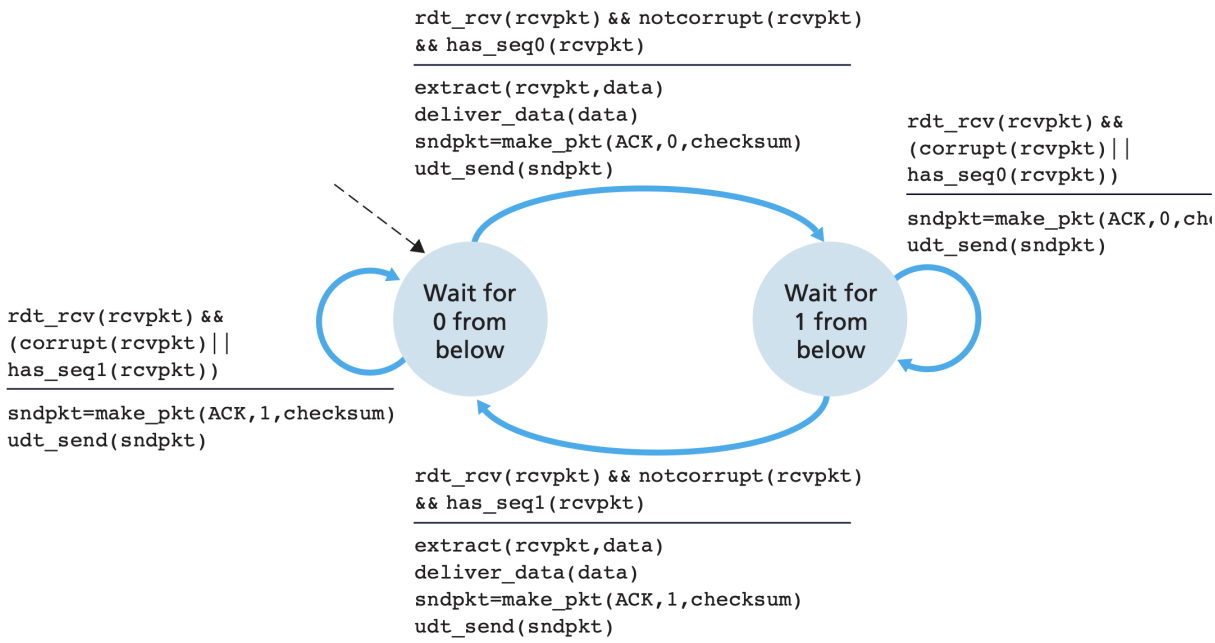
Question 1: Reliable Data Transfer

Design the protocol state machines for S and R (both R1 and R2 should use the same protocol).

- Using rdt3.0, a protocol that reliably transfers data over a channel that can corrupt or lose packets.
  - rdt_send(data)
  - Wait for ACK 0
  - rdt_rcv(rcvpkt) && (corrupt(rcvpkt) || isACK(rcvpkt,1))
  - rdt_rcv(rcvpkt) && notcorrupt(rcvpkt) && isACK(rcvpkt,0)
  - Wait for call 1 from above
  - rdt_send(data)
  - Wait for ACK 1
  - rdt_rcv(rcvpkt) && (corrupt(rcvpkt) || isACK(rcvpkt,0))
  - rdt_rcv(rcvpkt) && notcorrupt(rcvpkt) && isACK(rcvpkt,1)
  - Wait for call 0 from above
- Sender: rdt3.0 sender which can judiciously choose a time value such that packet loss is likely, although not guaranteed, to have happened. If an ACK is not received within this time, the packet is retransmitted.



- Receiver: rdt2.2 receiver which can use checksumming, sequence numbers, ACK packets, and retransmissions to handle packet loss.



Question 2: Throttling

What is the difference between flow control and congestion control?

- Flow Control is an end-to-end mechanism that controls the traffic between a sender and a receiver. Flow control occurs in the data link layer and the transport layer.
- Congestion control is used to control congestion in the network. Congestion Control is handled by the network layer and the transport layer.

Describe the way TCP implements each of these features.

- TCP provides flow control by having the sender maintain a variable called the receive window, which is used to give the sender an idea of how much free buffer space is available at the receiver. Because TCP is full-duplex, the sender at each side of the connection maintains a distinct receive window.
- TCP provides congestion control by having each sender limit the rate at which it sends traffic into its connection as a function of perceived network congestion. If a TCP sender perceives that there is little congestion on the path between itself and the destination, then the TCP sender increases its send rate; if the sender perceives that there is congestion along the path, then the sender reduces its send rate.

Question 3: NAT

What are possible values for the source and destination addresses and ports for packets?

	Source	Destination
from A to X behind the NAT	10.0.0.1:1025 - 65365	1.2.3.4:80
from B to X behind the NAT	10.0.0.2:1025 - 65365	1.2.3.4:80

	Source	Destination
from A to X between the NAT and X	5.6.7.8:1025 - 65365	1.2.3.4:80
from B to X between the NAT and X	5.6.7.8:1025 - 65365	1.2.3.4:80
from X to A between X and the NAT	1.2.3.4:80	5.6.7.8:1025 - 65365
from X to A between the NAT and A	1.2.3.4:80	10.0.0.1:1025 - 65365

What there corresponding contents of the router's NAT translation table?

- Port numbers
- IP addresses

Question 4: Routers

How many subnets are a part of this network, and what is the smallest IP prefix (i.e. most fixed bits) that can be used to describe each one?

- 6 subnets.
- A: 1.1.1
- B: 1.1.2
- C: 1.1.3
- A/B: 1.1.4
- A/C: 1.1.5
- B/C: 1.1.6

If this network is somehow connected to the internet, what is the cheapest (i.e. smallest number of address) IP prefix the company could have purchased (without using NAT)?

- 1.1.1 - 1.1.6

Assume the router for group A has 4 ports: port 1 is connected to the group subnet, port 2 is connected to router B, port 3 is connected to router C, and port D is connected to the ISP. Write out router A's forwarding table.

header value	output link
1.1.1	A
1.1.4	Router B
1.1.5	Router C
1.1.7	ISP

Question 5: Routing

```
package msd.benjones;

import java.util.HashMap;
import java.util.HashSet;
import java.util.Set;

public class Router {

    private HashMap<Router, Integer> distances;
    private String name;
    public Router(String name) {
        this.distances = new HashMap<>();
        this.name = name;
    }

    public void onInit() throws InterruptedException {

        //TODO: IMPLEMENT ME
        //As soon as the network is online,
        //fill in your initial distance table and broadcast it to your neighbors

        HashSet<Neighbor> neighbors = Network.getNeighbors(this);

        // fill in initial distance table
        for (Router curRouter : Network.getRouters()) {
            if (curRouter == this) {
                distances.put(curRouter, 0);
            }
            else {
                distances.put(curRouter, Integer.MAX_VALUE);
            }
        }

        for (Neighbor curNeighbor : neighbors) {
            distances.put(curNeighbor.router, curNeighbor.cost);
        }

        // broadcast it to the neighbors
        for (Neighbor curNeighbor : neighbors) {
            Message message = new Message(this, curNeighbor.router, distances);
            Network.sendDistanceMessage(message);
        }
    }

    public void onDistanceMessage(Message message) throws InterruptedException {
        //update your distance table and broadcast it to your neighbors if it changed

        if (this == message.receiver) {
            for (Router curRouter : Network.getRouters()) {
                int curDistance = message.distances.get(curRouter) + this.distances.get(message.sender)

                if (message.distances.get(curRouter) != 0 &&
```

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                    message.distances.get(curRouter) != Integer.MAX_VALUE &&
                    curDistance < this.distances.get(curRouter) &&
                    this.distances.get(message.sender) != 0) {

                    // broadcast it to your neighbors if it changed
                    this.distances.put(curRouter, curDistance);

                    Message broadcast = new Message(this, curRouter, distances);
                    Network.sendDistanceMessage(broadcast);
                }
            }
        }
    }


    public void dumpDistanceTable() {
        System.out.println("router: " + this);
        for(Router r : distances.keySet()){
            System.out.println("\t" + r + "\t" + distances.get(r));
        }
    }

    @Override
    public String toString(){
        return "Router: " + name;
    }
}
```