Programming Assignment 1: Implemented a distributed, asynchronous distance vector routing algorithm

Web posted: Feb 24, 10:30 hrs
Due: March 9, 12:00pm

VIP/NTU students: Due two weeks from when you receive this assignment or view lecture 9, whichever is later.

Important Note: You are expected to do and hand in *only* the advanced assignment. However, as noted below, it may be useful if you did the basic assignment first (we don't require you to do so, nor are there any points for the basic assigmnent).

Overview

In this lab, you will be writing a ``distributed'' set of procedures that implement a distributed asynchronous distance vector routing for the network shown in Figure Lab.4-1.

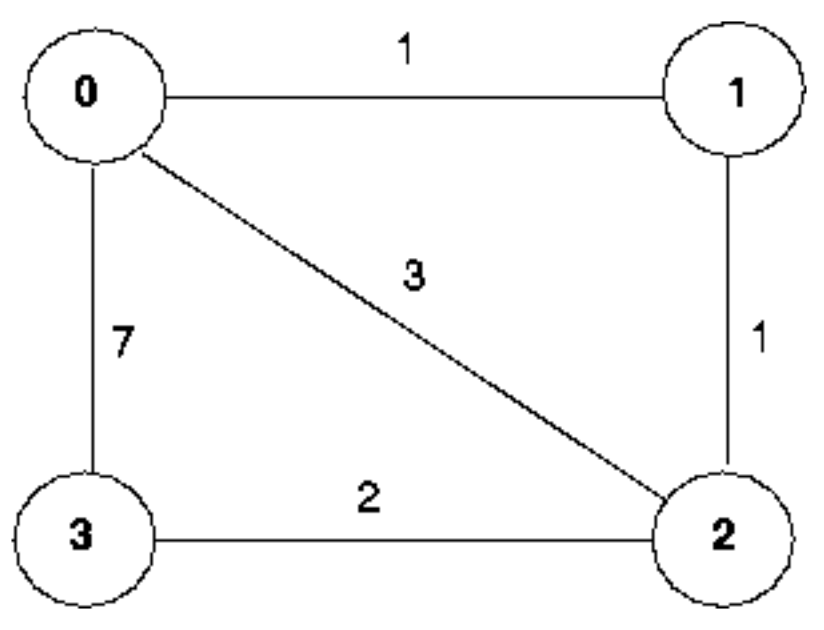

Figure Lab.4-1: Network topology and link costs for DV routing lab

The Basic Assignment

The routines you will write For the basic part of the assignment, you are to write the following routines which will ``execute'' asynchronously within the emulated environment that we have written for this assignment.

For node 0, you will write the routines:

- `rtinit0()` This routine will be called once at the beginning of the emulation. `rtinit0()` has no arguments. It should initialize the distance table in node 0 to reflect the direct costs of 1, 3, and 7 to nodes 1, 2, and 3, respectively. In Figure 1, all links are bi-directional and the costs in both directions are identical. After initializing the distance table, and any other data structures needed by your node 0 routines, it should then send its directly-connected neighbors (in this case, 1, 2 and 3) the cost of it minimum cost paths to all other network nodes. This minimum cost information is sent to neighboring nodes in a *routing packet* by calling the routine `tolayer2()`, as described below. The format of the routing packet is also described below.
- `rtupdate0(struct rtpkt *rcvdpkt)`. This routine will be called when node 0 receives a routing packet that was sent to it by one if its directly connected neighbors. The parameter `*rcvdpkt` is a pointer to the packet that was received.

  `rtupdate0()` is the ``heart'' of the distance vector algorithm. The values it receives in a routing packet from some other node *i* contain *i*'s current shortest path costs to all other network nodes. `rtupdate0()` uses these received values to update its own distance table (as specified by the distance vector algorithm). If its own minimum cost to another node changes as a result of the update, node 0 informs its directly connected neighbors of this change in minimum cost by sending them a routing packet. Recall that in the distance vector algorithm, only directly connected nodes will exchange routing packets. Thus nodes 1 and 2 will communicate with each other, but nodes 1 and 3 will ~~node~~ not communicate with each other.

  As we saw in class, the distance table inside each node is the principal data structure used by the distance vector algorithm. You will find it convenient to declare the distance table as a 4-by-4 array of `int`'s, where entry `[i,j]` in the distance table in node 0 is node 0's currently computed cost to node i via direct neighbor j. If 0 is not directly connected to *j*, you can ignore this entry. We will use the convention that the integer value 999 is ``infinity.''

  Figure Lab.4-2 provides a conceptual view of the relationship of the procedures inside node 0.

Similar routines are defined for nodes 1, 2 and 3. Thus, you will write 8 procedures in all: `rtinit0(), rtinit1(), rtinit2(), rtinit3(),rtupdate0(), rtupdate1(), rtupdate2(), rtupdate3()`

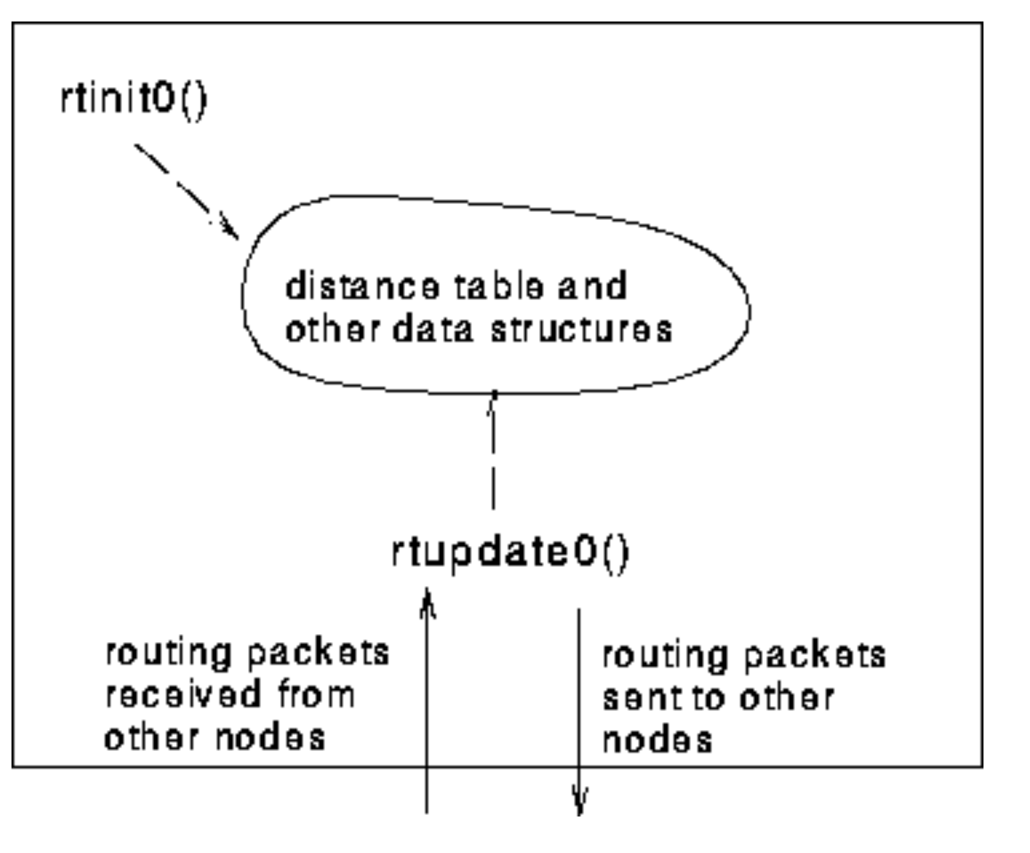

Figure Lab.4-2: Relationship between procedures inside node 0

Software Interfaces

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

`tolayer2(struct rtpkt pkt2send)`
: where `rtpkt` is the following structure, which is already declared for you. The procedure `tolayer2()` is defined in the file prog1.c

```
extern struct rtpkt {
  int sourceid;       /* id of node sending this pkt, 0, 1, 2, or 3  */
  int destid;         /* id of router to which pkt being sent
                         (must be an immediate neighbor) */
  int mincost[4];    /* min cost to node 0 ... 3 */
  };
```

Note that `tolayer2()` is passed a structure, not a pointer to a structure.

`printdt0()`
: will pretty print the distance table for node 0. It is passed a pointer to a structure of type `distance_table`. `printdt0()` and the structure declaration for the node 0 distance table are declared in the file `node0.c`. Similar pretty-print routines are defined for you in the files `node1.c, node2.c node3.c`.

The simulated network environment

Your procedures `rtinit0(), rtinit1(), rtinit2(), rtinit3()` and `rtupdate0(), rtupdate1(), rtupdate2(), rtupdate3()` send routing packets (whose format is described above) into the medium. The medium will deliver packets in-order, and without loss to the specified destination. Only directly-connected nodes can communicate. The delay between is sender and receiver is variable (and unknown).

When you compile your procedures and my procedures together and run the resulting program, you will be asked to specify only one value regarding the simulated network environment:

- **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!

The Basic Assignment

You are to write the procedures `rtinit0(), rtinit1(), rtinit2(), rtinit3()` and `rtupdate0(), rtupdate1(), rtupdate2(), rtupdate3()` which together will implement a distributed, asynchronous computation of the distance tables for the topology and costs shown in Figure 1.

You should put your procedures for nodes 0 through 3 in files called node0.c, ... node3.c. You are **NOT** allowed to declare any global variables that are visible outside of a given C file (e.g., any global variables you define in `node0.c.` may only be accessed inside `node0.c`). This is to force you to abide by the coding conventions that you would have to adopt is you were really running the procedures in four distinct nodes. To compile your routines: `cc prog1.c node0.c node1.c node2.c node3.` Prototype versions of these files are here: node0.c, node1.c, node2.c, node3.c. You can pick up a copy of the file prog1.c at http://www.cs.umass.edu/~shenoy/courses/653/homeworks/prog1/prog1.c.

This assignment can be completed on any machine supporting C. It makes no use of UNIX features.

As always, most instructors would expect you to hand in a code listing, a design document, and sample output.

For your sample output, your procedures should print out a message whenever your `rtinit0(), rtinit1(), rtinit2(), rtinit3()` or `rtupdate0(), rtupdate1(), rtupdate2(), rtupdate3()` procedures are called, giving the time (available via my global variable `clocktime`). For `rtupdate0(), rtupdate1(), rtupdate2(), rtupdate3()` you should print the identity of the sender of the routing packet that is being passed to your routine, whether or not the distance table is updated, the contents of the distance table (you can use my pretty-print routines), and a description of any messages sent to neighboring nodes as a result of any distance table updates.

The sample output should be an output listing with a TRACE value of 2. Highlight the final distance table produced in each node. Your program will run until there are no more routing packets in-transit in the network, at which point our emulator will terminate.

The Advanced Assignment

You are to write two procedures, `rtlinkhandler0(int linkid, int newcost)` and `rtlinkhandler1(int linkid, int newcost)`, which will be called if (and when) the cost of the link between 0 and 1 changes. These routines should be defined in the files `node0.c` and `node1.c`, respectively. The routines will be passed the name (id) of the neighboring node on the other side of the link whose cost has changed, and the new cost of the link. Note that when a link cost changes, these routines will have to update the distance table and may (or may not) have to send updated routing packets to neighboring nodes.

In order to complete the advanced part of the assignment, you will need to change the value of the constant LINKCHANGES (line 3 in `prog1.c)` to 1. FYI, the cost of the link will change from 1 to 20 at time 10000 and then change back to 1 at time 20000. Your routines will be invoked at these times.

We would again **STRONGLY** recommend that you first implement the undergraduate assignment and then extend your code to implement the graduate assignment. It will **not** be time wasted. (Believe me, I learned this the hard way!)