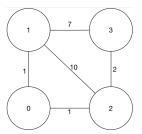
## 1. Overall Design And How It Works

a. The program is a "distributed" set of procedures that implement a distributed distance vector routing for the network shown in Figure.



- b. The program is edited from the skeleton code that professor provided. Three procedures I wrote are rtinit(), rtupdate() and rtlinkhandler() which together implemented a distributed, asynchronous computation of the distance tables for the topology and costs shown in figure. It allows link cost change and follows split horizon with poison reverse heuristic.
- c. With tracing value of 1 or 2, the output will have useful information about what is going on inside the emulation. A tracing value of 0 will turn this off. Seed is the seed of the pseudo-random generator used by the simulator.
- d. For more information of functions, see in-code comments.

## 2. Compilation instructions

This is the Java Version of the program.

To compile: javac \*.java To run: java Project3

To clean up: rm -rf \*- \*.class

## 3. Sample output

```
Network Simulator v1.0
Enter trace level (>= 0): [0] 2
Enter seed (>= 0): [3322] 2
Function rtinit() has been called at t=0.000000 to initialize node 0.
A packet has been sent from node 0 to node 1, contents = 0 1 1 9999
A packet has been sent from node 0 to node 2, contents = 0 1 1 9999
Distance table of node 0 is:
         via
  D0 |
               2
          1
         1 9999
      1 |
dest 2| 9999
               1
      3 | 9999 9999
Function rtinit() has been called at t=0.000000 to initialize node 1.
A packet has been sent from node 1 to node 0, contents = 1 0 10 7
```

A packet has been sent from node 1 to node 2, contents =  $1\ 0\ 10\ 7$  A packet has been sent from node 1 to node 3, contents =  $1\ 0\ 10\ 7$ 

Distance table of node 1 is:

Function rtinit() has been called at t=0.000000 to initialize node 2.

A packet has been sent from node 2 to node 0, contents =  $1\ 10\ 0\ 2$  A packet has been sent from node 2 to node 1, contents =  $1\ 10\ 0\ 2$  A packet has been sent from node 2 to node 3, contents =  $1\ 10\ 0\ 2$ 

Distance table of node 2 is:

Function rtinit() has been called at t=0.000000 to initialize node 3.

A packet has been sent from node 3 to node 1, contents = 9999720 A packet has been sent from node 3 to node 2, contents = 9999720

Distance table of node 3 is:

MAIN: rcv event, t=0.055, at 1 src: 0, dest: 1, contents: 0 9999 1 9999 Distance table has been updated.

Distance table of node 1 is:

A packet has been sent from node 1 to node 0, contents = 9999 0 9999 7 A packet has been sent from node 1 to node 2, contents = 1 0 2 7 A packet has been sent from node 1 to node 3, contents = 1 0 2 9999 MAIN: rcv event, t=0.625, at 0 src: 1, dest: 0, contents: 9999 0 10 7 Distance table has been updated.

A packet has been sent from node 0 to node 1, contents = 0 9999 1 9999 A packet has been sent from node 0 to node 2, contents = 0 1 9999 8 MAIN: rcv event, t=1.393, at 2 src: 0, dest: 2, contents: 0 1 9999 9999 Distance table has been updated.

Distance table of node 2 is:

A packet has been sent from node 2 to node 0, contents = 9999 9999 0 2 A packet has been sent from node 2 to node 1, contents = 1 2 0 2 A packet has been sent from node 2 to node 3, contents = 1 2 0 9999 MAIN: rcv event, t=1.577, at 3 src: 1, dest: 3, contents: 1 0 10 9999 Distance table has been updated.

Distance table of node 3 is:

A packet has been sent from node 3 to node 1, contents = 9999 9999 2 0 A packet has been sent from node 3 to node 2, contents = 8 7 9999 0 MAIN: rcv event, t=1.885, at 1 src: 2, dest: 1, contents: 1 9999 0 2 Distance table has been updated.

Distance table of node 1 is:

MAIN: rcv event, t=2.181, at 2 src: 1, dest: 2, contents: 1 0 9999 7 Distance table has been updated.

Distance table of node 2 is:

```
via
D2 | 0 1 3
---|-----
0 | 1 11 9999
dest 1 | 2 10 9999
3 | 9999 17 2
```

MAIN: rcv event, t=2.279, at 0 src: 2, dest: 0, contents: 9999 10 0 2

Distance table has been updated.

Distance table of node 0 is:

A packet has been sent from node 0 to node 1, contents = 0 9999 1 3 A packet has been sent from node 0 to node 2, contents = 0 1 9999 9999 MAIN: rcv event, t=3.124, at 1 src: 3, dest: 1, contents: 9999 9999 2 0 Distance table has been updated.

Distance table of node 1 is:

MAIN: rcv event, t=3.278, at 3 src: 2, dest: 3, contents: 1 10 0 9999 Distance table has been updated.

Distance table of node 3 is:

Distance table of node 0 is:

MAIN: rcv event, t=4.001, at 1 src: 0, dest: 1, contents: 0 9999 1 9999 Distance table has not been updated.

Distance table of node 1 is:

MAIN: rcv event, t=4.041, at 3 src: 1, dest: 3, contents: 1 0 2 9999 Distance table has been updated.

Distance table of node 3 is:

MAIN: rcv event, t=4.167, at 2 src: 3, dest: 2, contents: 9999 7 9999 0 Distance table has been updated.

Distance table of node 2 is:

MAIN: rcv event, t=4.428, at 0 src: 2, dest: 0, contents: 9999 9999 0 2 Distance table has been updated.

Distance table of node 0 is:

MAIN: rcv event, t=5.026, at 3 src: 2, dest: 3, contents: 1 2 0 9999 Distance table has been updated.

Distance table of node 3 is:

A packet has been sent from node 3 to node 1, contents =  $3\ 4\ 2\ 0$  A packet has been sent from node 3 to node 2, contents =  $9999\ 9999\ 0$  MAIN: rcv event, t=5.088, at 1 src: 2, dest: 1, contents: 1 2 0 2 Distance table has not been updated.

Distance table of node 1 is:

MAIN: rcv event, t=5.228, at 1 src: 3, dest: 1, contents: 9999 9999 2 0 Distance table has not been updated.

Distance table of node 1 is:

MAIN: rcv event, t=5.269, at 1 src: 0, dest: 1, contents: 0 9999 1 3 Distance table has been updated.

Distance table of node 1 is:

A packet has been sent from node 1 to node 0, contents = 9999 0 9999 9999 A packet has been sent from node 1 to node 2, contents = 1 0 2 4 A packet has been sent from node 1 to node 3, contents = 1 0 2 4 MAIN: rcv event, t=6.074, at 2 src: 1, dest: 2, contents: 1 0 2 7 Distance table has not been updated.

Distance table of node 2 is:

MAIN: rcv event, t=6.216, at 3 src: 1, dest: 3, contents: 1 0 2 4 Distance table has not been updated.

//final distance table for node 3 before link cost changes

MAIN: rcv event, t=6.363, at 1 src: 3, dest: 1, contents: 3 9999 2 0 Distance table has been updated.

MAIN: rcv event, t=6.457, at 0 src: 1, dest: 0, contents: 9999 0 9999 Distance table has been updated.

MAIN: rcv event, t=6.721, at 2 src: 0, dest: 2, contents: 0 1 9999 8 Distance table has been updated.

Distance table of node 2 is:

MAIN: rcv event, t=6.764, at 2 src: 3, dest: 2, contents: 8 7 9999 0 Distance table has been updated.

Distance table of node 2 is:

```
via
D2 | 0 1 3
---|------
0 | 1 11 10
dest 1 | 2 10 9
3 | 9 17 2
```

MAIN: rcv event, t=6.871, at 2 src: 0, dest: 2, contents: 0 1 9999 9999 Distance table has been updated.

Distance table of node 2 is:

```
via
D2 | 0 1 3
----|------
0 | 1 11 10
dest 1 | 2 10 9
3 | 9999 17 2
```

MAIN: rcv event, t=7.792, at 1 src: 3, dest: 1, contents: 3 4 2 0 Distance table has not been updated.

```
Distance table of node 1 is:
      via
   D1 | 0 2 3
    0 | 1 11 10
dest 2| 2 10 9
    3 | 4 | 12 | 7
******************
MAIN: rcv event, t=8.698, at 2 src: 3, dest: 2, contents: 9999 7 9999 0
Distance table has been updated.
Distance table of node 2 is:
    via
   D2 | 0 1 3
  ----|------
   0 | 1 11 9999
dest 1| 2 10 9
    3 | 9999 17 2
MAIN: rcv event, t=9.708, at 2 src: 3, dest: 2, contents: 9999 9999 9999 0
Distance table has been updated.
Distance table of node 2 is:
      via
   D2 | 0 1 3
  ---- | ------
    0 | 1 11 9999
dest 1| 2 10 9999
    3 | 9999 17 2
MAIN: rcv event, t=9.896, at 2 src: 1, dest: 2, contents: 1 0 2 4
Distance table has been updated.
//final distance table of node 2 before link cost changes
/****************
Distance table of node 2 is:
      via
 D2 | 0 1 3
 ----|------
 0 | 1 11 9999
dest 1| 2 10 9999
  3 | 9999 14 2
**********************
MAIN: rcv event, t=10000.000, at -1
Function linkhandler() has been called at t=10000.000000 for node 0 since link cost
  from node 0 to 1 has been changed to 20.
Distance table has been updated.
Distance table of node 0 is:
    via
   D0 | 1 2
  ----|------
    1| 20 9999
```

```
dest 2| 9999 1
3| 9999 3
```

A packet has been sent from node 0 to node 1, contents = 0 9999 1 3
A packet has been sent from node 0 to node 2, contents = 0 20 9999 9999
Function linkhandler() has been called at t=10000.000000 for node 1 since link cost from node 1 to 0 has been changed to 20.

Distance table has been updated.

Distance table of node 1 is:

A packet has been sent from node 1 to node 0, contents = 10 0 9 7
A packet has been sent from node 1 to node 2, contents = 10 0 9 7
A packet has been sent from node 1 to node 3, contents = 9999 0 9999 9999MAIN: rcv event, t=10000.796, at 1 src: 0, dest: 1, contents: 0 9999 1 3
Distance table has been updated.

Distance table of node 1 is:

MAIN: rcv event, t=10001.503, at 3 src: 1, dest: 3, contents: 9999 0 9999 Distance table has been updated.

Distance table of node 3 is:

MAIN: rcv event, t=10001.695, at 2 src: 0, dest: 2, contents: 0 20 9999 9999 Distance table has been updated.

Distance table of node 2 is:

A packet has been sent from node 2 to node 0, contents =  $9999 \ 10 \ 0 \ 2$  A packet has been sent from node 2 to node 1, contents =  $1 \ 9999 \ 0 \ 2$ 

A packet has been sent from node 2 to node 3, contents =  $1\ 10\ 0\ 9999$  MAIN: rcv event, t=10001.915, at 0 src: 1, dest: 0, contents:  $10\ 0\ 9\ 7$  Distance table has been updated.

Distance table of node 0 is:

MAIN: rcv event, t=10002.221, at 3 src: 2, dest: 3, contents: 1 10 0 9999 Distance table has been updated.

Distance table of node 3 is:

A packet has been sent from node 3 to node 1, contents = 3999920 A packet has been sent from node 3 to node 2, contents = 9999799990 MAIN: rcv event, t=10002.457, at 0 src: 2, dest: 0, contents: 99991002 Distance table has been updated.

Distance table of node 0 is:

A packet has been sent from node 0 to node 1, contents = 0 11 1 3 A packet has been sent from node 0 to node 2, contents = 0 9999 9999 MAIN: rcv event, t=10002.909, at 1 src: 2, dest: 1, contents: 1 9999 0 2 Distance table has not been updated.

Distance table of node 1 is:

MAIN: rcv event, t=10003.078, at 2 src: 1, dest: 2, contents: 10 0 9 7 Distance table has been updated.

Distance table of node 2 is:

```
dest 1| 21 10 9999
3| 9999 17 2
```

MAIN: rcv event, t=10003.514, at 2 src: 3, dest: 2, contents: 9999 7 9999 0 Distance table has been updated.

Distance table of node 2 is:

A packet has been sent from node 2 to node 0, contents = 9999 9 0 2 A packet has been sent from node 2 to node 1, contents = 1 9 0 2 A packet has been sent from node 2 to node 3, contents = 1 9999 0 9999 MAIN: rcv event, t=10003.537, at 1 src: 3, dest: 1, contents: 3 9999 2 0 Distance table has not been updated.

Distance table of node 1 is:

MAIN: rcv event, t=10003.553, at 1 src: 0, dest: 1, contents: 0 11 1 3 Distance table has not been updated.

Distance table of node 1 is:

MAIN: rcv event, t=10003.745, at 2 src: 0, dest: 2, contents: 0 9999 9999 Distance table has been updated.

Distance table of node 2 is:

MAIN: rcv event, t=10004.351, at 3 src: 2, dest: 3, contents: 1 9999 0 9999 Distance table has been updated.

```
D3 | 1 2
  ----|-----
   0| 9999 3
dest 1| 7 9999
   21 9999 2
*******************
MAIN: rcv event, t=10004.758, at 0 src: 2, dest: 0, contents: 9999 9 0 2
Distance table has been updated.
//final distance table for node 0 after link cost changes
/********************
Distance table of node 0 is:
      via
   D0 | 1 2
  ----
   1 | 20 | 10
dest 2| 29 1
    3 | 27
******************
A packet has been sent from node 0 to node 1, contents = 0 10 1 3
A packet has been sent from node 0 to node 2, contents = 0 9999 9999 9999
MAIN: rcv event, t=10005.182, at 2 src: 0, dest: 2, contents: 0 9999 9999 9999
Distance table has not been updated.
//final distance table for node 2 after link cost changes
/********************
Distance table of node 2 is:
      via
  D2 | 0 1 3
   0| 1 20 9999
dest 1| 9999 10 9
    3 | 9999 17 2
************************
MAIN: rcv event, t=10005.526, at 1 src: 2, dest: 1, contents: 1 9 0 2
Distance table has not been updated.
Distance table of node 1 is:
      via
   D1 | 0 2 3
  ---- | ------
    0 | 20 11 10
dest 2| 21 10 9
    3 | 23 12
MAIN: rcv event, t=10005.597, at 1 src: 0, dest: 1, contents: 0 10 1 3
Distance table has not been updated.
//final distance table for node 1 after link cost changes
/****************
Distance table of node 1 is:
      via
   D1 | 0 2 3
  ____|____
```

MAIN: rcv event, t=20000.000, at -1

Function linkhandler() has been called at t=20000.000000 for node 0 since link cost from node 0 to 1 has been changed to 1.

Distance table has been updated.

Distance table of node 0 is:

A packet has been sent from node 0 to node 1, contents = 0 9999 1 3

A packet has been sent from node 0 to node 2, contents = 0 1 9999 9999

Function linkhandler() has been called at t=20000.000000 for node 1 since link cost from node 1 to 0 has been changed to 1.

Distance table has been updated.

Distance table of node 1 is:

A packet has been sent from node 1 to node 0, contents = 9999 0 9 7
A packet has been sent from node 1 to node 2, contents = 1 0 9 7
A packet has been sent from node 1 to node 3, contents = 1 0 9999 9999MAIN: rcv event, t=20000.019, at 3 src: 1, dest: 3, contents: 1 0 9999 9999

Distance table has been updated.

Distance table of node 3 is:

MAIN: rcv event, t=20000.022, at 0 src: 1, dest: 0, contents: 9999 0 9 7 Distance table has been updated.

Distance table of node 0 is:

```
via
D0 | 1 2
```

MAIN: rcv event, t=20000.421, at 2 src: 0, dest: 2, contents: 0 1 9999 9999 Distance table has been updated.

Distance table of node 2 is:

A packet has been sent from node 2 to node 0, contents = 9999 9999 0 2 A packet has been sent from node 2 to node 1, contents = 1 2 0 2 A packet has been sent from node 2 to node 3, contents = 1 2 0 9999 MAIN: rcv event, t=20000.699, at 1 src: 0, dest: 1, contents: 0 9999 1 3 Distance table has been updated.

Distance table of node 1 is:

A packet has been sent from node 1 to node 0, contents = 9999 0 9999 9999 A packet has been sent from node 1 to node 2, contents =  $1\ 0\ 2\ 4$  A packet has been sent from node 1 to node 3, contents =  $1\ 0\ 2\ 4$  MAIN: rcv event, t=20001.739, at 0 src: 2, dest: 0, contents: 9999 9999 0 2 Distance table has been updated.

Distance table of node 0 is:

MAIN: rcv event, t=20002.052, at 2 src: 1, dest: 2, contents: 1 0 9 7 Distance table has been updated.

Distance table of node 2 is:

```
via

D2 | 0 1 3

----|------

0 | 1 11 9999

dest 1 | 2 10 9

3 | 9999 17 2
```

MAIN: rcv event, t=20002.211, at 3 src: 2, dest: 3, contents: 1 2 0 9999 Distance table has been updated.

```
Distance table of node 3 is:
      via
   D3 | 1
  ----|------
    01 8 3
dest 1| 7 4
    2 | 9999 2
A packet has been sent from node 3 to node 1, contents = 3 4 2 0
A packet has been sent from node 3 to node 2, contents = 9999 9999 9999 0
MAIN: rcv event, t=20002.309, at 1 src: 2, dest: 1, contents: 1 2 0 2
Distance table has not been updated.
Distance table of node 1 is:
      via
   D1 | 0 2 3
  ----|------
   0 | 1 11 10
dest 2| 2 10 9
    3 | 4 12 7
MAIN: rcv event, t=20002.679, at 0 src: 1, dest: 0, contents: 9999 0 9999 9999
Distance table has been updated.
//final distance table for node 0 after link cost changes back
/*********************
Distance table of node 0 is:
      via
  D0 | 1 2
  ----|------
    1 | 1 9999
dest 2| 9999 1
    3 | 9999 3
************************************
MAIN: rcv event, t=20003.013, at 1 src: 3, dest: 1, contents: 3 4 2 0
Distance table has not been updated.
//final distance table for node 1 after link cost changes back
/********************
Distance table of node 1 is:
      via
  D1 | 0 2 3
  ----|------
    0| 1 11 10
dest 2| 2 10 9
    3 | 4 | 12 | 7
*******************
MAIN: rcv event, t=20003.661, at 2 src: 1, dest: 2, contents: 1 0 2 4
Distance table has been updated.
Distance table of node 2 is:
      via
   D2 | 0 1 3
  ----|------
    0 | 1 11 9999
```

```
dest 1|
       2 10
    3 | 9999 14
MAIN: rcv event, t=20004.166, at 3 src: 1, dest: 3, contents: 1 0 2 4
Distance table has been updated.
//final distance table for node 3 after link cost changes back
/********************
Distance table of node 3 is:
      via
   D3 | 1 2
  ----|------
    0 | 8 3
dest 1| 7 4
    2 | 9 2
***********************************
MAIN: rcv event, t=20004.197, at 2 src: 3, dest: 2, contents: 9999 9999 0
Distance table has been updated.
//final distance table for node 2 after link cost changes back
/*******************
Distance table of node 2 is:
      via
   D2 | 0 1 3
    0 | 1 11 9999
dest 1| 2 10 9999
    3 | 9999 14 2
********************
Simulator terminated at t=20004.196844, no packets in medium
Simulator terminated at time 20004.196844386122
```