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CS244a, Project-2
Final Report

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Objective

To implement link-state routing protocol (employing Dijkstra' s algorithm) using BSD sockets interface for networking among routers.

Approach and Implementation Details

- **Initial Topology Information**
  A router reads its router startup file (in the specified format) and learns about its neighboring routers.
- **Connection Establishment**
  Between every router and its neighbor, a separate TCP connection is established.
  The end with the higher IP address is made the passive end and the one with lower IP address, the active one. A given router waits for all active ends to connect to it before connecting actively to other routers.
  When the active end tries to connect to the passive end and the passive end is not waiting for a connection, the active end waits a second and retries, i.e., *when attempting to connect to a neighbor, if a node is unsuccessful (connect calls fails), then the socket is closed, sleep(1) is called and socket and connect calls are reinvoked. The process is repeated till connection is established.*
  A passive end communicates with the active peers on a port number specified as an input to the program. The active peers are given ephemeral port numbers on success of the connect call.
- **Algorithm Phase**
  Once all TCP connections have been established for a router, the router sends its link-state information to each of its directly connected routers. The LSP containing information about router name, its neighbors and link costs, is constructed and written to all neighboring sockets. These router neighbors read the LSP from the pertinent socket and parse it to retrieve topology information. The LSP is forwarded to all the neighbors *except the one from which LSP was received*. When a router receives link-state information that it has already seen, it does not forward that information.
  On receiving a Link State Packet, topology is updated and Dijkstra's algorithm is run to update the routing table at the given node. Once a router does not receive any link state information for 10 seconds, it assumes that it will not receive any more link-state information. Dijkstra's algorithm when run at this stage gives the final routing table.
  Implementation Details:
  - ✓ Select call is executed to check if some sockets are ready for being read. If this is the case, the **FD_ISSET** function is used to check if a peer connection is ready for read. Data is read character by character from each active socket. The process is repeated while select call indicates that there is a socket ready to be read. If the sentinel character '$' is encountered, the LSP is retrieved from the buffer and the buffer corresponding to the peer from which LSP has been received is flushed.

- ✓ When **read** call returns a zero, it can be inferred that the peer has terminated the connection from the other end. This is so because read is a blocking call. Therefore, the router **terminates connection** to a peer **when read returns zero** from the corresponding socket.
- ✓ It is possible that when a router is waiting for data arrival (i.e., executing select call), a peer router terminates the connection at the other end; the waiting phase of the select call will then stop. Then, if the data from all sockets has already arrived and the termination of waiting phase of select call is caused by connection termination by a peer, the waiting time should be updated (decreased by the time the router has already waited) **to ensure that the router does not start the waiting period of 10 seconds** all over again. So this aspect is taken care of by using **gettimeofday** call to determine the waited time.

The Output

The Dijkstra's algorithm is run on the network, and the final routing table is formulated. Routing table is written to a file called "<**hostname>.table**". The routing table contains the cost and next hop information for reaching all destinations in the topology. The routing table entries are **sorted first on total cost and then on destination hostname** (using string comparison of router names).
The files " **<hostname>.output"** contains the routing tables and topology information known to a node, every time a Link State Packet is received.

Program Testing and Results:

The program runs correctly when tested on a several topologies consisting of 2, 3, 5 and more nodes. The results are presented for the sample 5 node topology specified in the Figure below (taken from Project-2 handout):

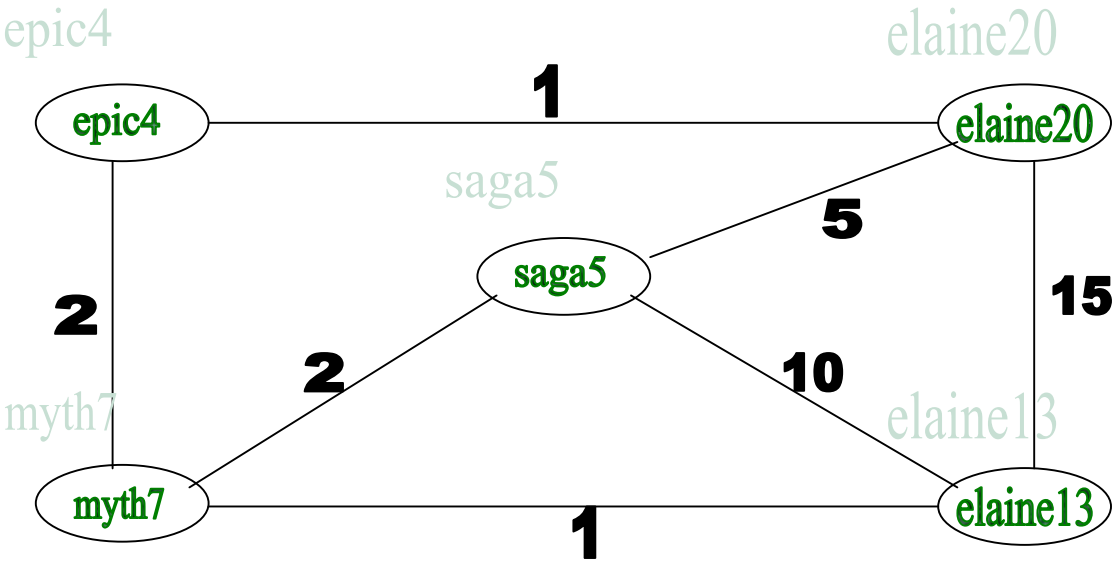
- The routing table produced at each router in the topology, is enclosed.
- In addition, the topology and routing table information inferred by each node every time a link state packet is received, is enclosed. The final topology information and routing tables are produced at the end of each respective file.

Useful Experiences:

The project provided enriching exposure vis-a-vis:

- Networking API and BSD sockets.
- TCP connection establishment, read write operations, and connection closure.
- Implementation of Dijkstra's routing algorithm and seeing it work.

Figure below shows that topology which includes five routers. The numbers on the links represent the link costs.


epic4
elaine20
1
saga5
5
2
15
2
10
myth7
elaine13
1

Routing Table at Every host (contents of the files <router>.table)

<<File epic4.stanford.edu.table>>

```
ROUTING TABLE FOR ROUTER: epic4.stanford.edu

elaine20.stanford.edu;elaine20.stanford.edu;1
myth7.stanford.edu;myth7.stanford.edu;2
elaine13.stanford.edu;myth7.stanford.edu;3
saga5.stanford.edu;myth7.stanford.edu;4
```

<<File elaine20.stanford.edu.table>>

```
ROUTING TABLE FOR ROUTER: elaine20.stanford.edu

epic4.stanford.edu;epic4.stanford.edu;1
myth7.stanford.edu;epic4.stanford.edu;3
elaine13.stanford.edu;epic4.stanford.edu;4
saga5.stanford.edu;saga5.stanford.edu;5
```

<<File saga5.stanford.edu.table>>

```
ROUTING TABLE FOR ROUTER: saga5.stanford.edu

myth7.stanford.edu;myth7.stanford.edu;2
elaine13.stanford.edu;myth7.stanford.edu;3
epic4.stanford.edu;myth7.stanford.edu;4
elaine20.stanford.edu;elaine20.stanford.edu;5
```

<<File myth7.stanford.edu.table>>

```
ROUTING TABLE FOR ROUTER: myth7.stanford.edu

elaine13.stanford.edu;elaine13.stanford.edu;1
epic4.stanford.edu;epic4.stanford.edu;2
saga5.stanford.edu;saga5.stanford.edu;2
elaine20.stanford.edu;epic4.stanford.edu;3
```

<<File elaine13.stanford.edu.table>>

```
ROUTING TABLE FOR ROUTER: elaine13.stanford.edu

myth7.stanford.edu;myth7.stanford.edu;1
epic4.stanford.edu;myth7.stanford.edu;3
saga5.stanford.edu;myth7.stanford.edu;3
elaine20.stanford.edu;myth7.stanford.edu;4
```

Topology and Link State Information on Receiving an LSP
File: epic4.output
Router: epic4.stanford.edu

```
      PRINTING INITIAL TOPOLOGY
*** Router Name: epic4.stanford.edu
--- Neighbors:
    + elaine20.stanford.edu (1)
    + myth7.stanford.edu (2)
*** Router Name: elaine20.stanford.edu
--- Neighbors:
    + epic4.stanford.edu (1)
*** Router Name: myth7.stanford.edu
--- Neighbors:
    + epic4.stanford.edu (2)

      PRINTING INITIAL ROUTING TABLE
elaine20.stanford.edu;elaine20.stanford.edu;1
myth7.stanford.edu;myth7.stanford.edu;2

---------------------------------------------------------------------

       PRINTING TOPOLOGY AFTER RECEINVING LSP:
myth7.stanford.edu:(saga5.stanford.edu;2)(elaine13.stanford.edu;1)(epic4
.stanford.edu;2)$
      FROM myth7.stanford.edu

*** Router Name: epic4.stanford.edu
--- Neighbors:
    + elaine20.stanford.edu (1)
    + myth7.stanford.edu (2)
*** Router Name: elaine20.stanford.edu
--- Neighbors:
    + epic4.stanford.edu (1)
*** Router Name: myth7.stanford.edu
--- Neighbors:
    + saga5.stanford.edu (2)
    + elaine13.stanford.edu (1)
    + epic4.stanford.edu (2)
*** Router Name: saga5.stanford.edu
--- Neighbors:
    + myth7.stanford.edu (2)
*** Router Name: elaine13.stanford.edu
--- Neighbors:
    + myth7.stanford.edu (1)

       PRINTING ROUTING TABLE
elaine20.stanford.edu;elaine20.stanford.edu;1
myth7.stanford.edu;myth7.stanford.edu;2
saga5.stanford.edu;myth7.stanford.edu;4
elaine13.stanford.edu;myth7.stanford.edu;3
```

```
       PRINTING TOPOLOGY AFTER RECEINVING LSP:
elaine20.stanford.edu:(elaine13.stanford.edu;15)(saga5.stanford.edu;5)(e
pic4.stanford.edu;1)$
      FROM elaine20.stanford.edu

*** Router Name: epic4.stanford.edu
--- Neighbors:
    + elaine20.stanford.edu (1)
    + myth7.stanford.edu (2)
*** Router Name: elaine20.stanford.edu
--- Neighbors:
    + elaine13.stanford.edu (15)
    + saga5.stanford.edu (5)
    + epic4.stanford.edu (1)
*** Router Name: myth7.stanford.edu
--- Neighbors:
    + saga5.stanford.edu (2)
    + elaine13.stanford.edu (1)
    + epic4.stanford.edu (2)
*** Router Name: saga5.stanford.edu
--- Neighbors:
    + myth7.stanford.edu (2)
    + elaine20.stanford.edu (5)
*** Router Name: elaine13.stanford.edu
--- Neighbors:
    + myth7.stanford.edu (1)
    + elaine20.stanford.edu (15)

       PRINTING ROUTING TABLE
elaine20.stanford.edu;elaine20.stanford.edu;1
myth7.stanford.edu;myth7.stanford.edu;2
saga5.stanford.edu;myth7.stanford.edu;4
elaine13.stanford.edu;myth7.stanford.edu;3

------------------------------------------------------------------------

       PRINTING TOPOLOGY AFTER RECEINVING LSP:
elaine13.stanford.edu:(elaine20.stanford.edu;15)(saga5.stanford.edu;10)(
myth7.stanford.edu;1)$
      FROM myth7.stanford.edu

*** Router Name: epic4.stanford.edu
--- Neighbors:
    + elaine20.stanford.edu (1)
    + myth7.stanford.edu (2)
*** Router Name: elaine20.stanford.edu
--- Neighbors:
    + elaine13.stanford.edu (15)
    + saga5.stanford.edu (5)
    + epic4.stanford.edu (1)
*** Router Name: myth7.stanford.edu
--- Neighbors:
    + saga5.stanford.edu (2)
    + elaine13.stanford.edu (1)
    + epic4.stanford.edu (2)
*** Router Name: saga5.stanford.edu
--- Neighbors:
```

```
    + myth7.stanford.edu (2)
    + elaine20.stanford.edu (5)
    + elaine13.stanford.edu (10)
*** Router Name: elaine13.stanford.edu
--- Neighbors:
    + elaine20.stanford.edu (15)
    + saga5.stanford.edu (10)
    + myth7.stanford.edu (1)

       PRINTING ROUTING TABLE
elaine20.stanford.edu;elaine20.stanford.edu;1
myth7.stanford.edu;myth7.stanford.edu;2
saga5.stanford.edu;myth7.stanford.edu;4
elaine13.stanford.edu;myth7.stanford.edu;3

------------------------------------------------------------------------

       PRINTING TOPOLOGY AFTER RECEINVING LSP:
saga5.stanford.edu:(elaine20.stanford.edu;5)(elaine13.stanford.edu;10)(m
yth7.stanford.edu;2)$
      FROM elaine20.stanford.edu

*** Router Name: epic4.stanford.edu
--- Neighbors:
    + elaine20.stanford.edu (1)
    + myth7.stanford.edu (2)
*** Router Name: elaine20.stanford.edu
--- Neighbors:
    + elaine13.stanford.edu (15)
    + saga5.stanford.edu (5)
    + epic4.stanford.edu (1)
*** Router Name: myth7.stanford.edu
--- Neighbors:
    + saga5.stanford.edu (2)
    + elaine13.stanford.edu (1)
    + epic4.stanford.edu (2)
*** Router Name: saga5.stanford.edu
--- Neighbors:
    + elaine20.stanford.edu (5)
    + elaine13.stanford.edu (10)
    + myth7.stanford.edu (2)
*** Router Name: elaine13.stanford.edu
--- Neighbors:
    + elaine20.stanford.edu (15)
    + saga5.stanford.edu (10)
    + myth7.stanford.edu (1)

       PRINTING ROUTING TABLE
elaine20.stanford.edu;elaine20.stanford.edu;1
myth7.stanford.edu;myth7.stanford.edu;2
saga5.stanford.edu;myth7.stanford.edu;4
elaine13.stanford.edu;myth7.stanford.edu;3

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```

```
      THE FINAL TOPOLOGY IS:
*** Router Name: epic4.stanford.edu
--- Neighbors:
    + elaine20.stanford.edu (1)
    + myth7.stanford.edu (2)
*** Router Name: elaine20.stanford.edu
--- Neighbors:
    + elaine13.stanford.edu (15)
    + saga5.stanford.edu (5)
    + epic4.stanford.edu (1)
*** Router Name: myth7.stanford.edu
--- Neighbors:
    + saga5.stanford.edu (2)
    + elaine13.stanford.edu (1)
    + epic4.stanford.edu (2)
*** Router Name: saga5.stanford.edu
--- Neighbors:
    + elaine20.stanford.edu (5)
    + elaine13.stanford.edu (10)
    + myth7.stanford.edu (2)
*** Router Name: elaine13.stanford.edu
--- Neighbors:
    + elaine20.stanford.edu (15)
    + saga5.stanford.edu (10)
    + myth7.stanford.edu (1)


      PRINTING FINAL ROUTING TABLE
elaine20.stanford.edu;elaine20.stanford.edu;1
myth7.stanford.edu;myth7.stanford.edu;2
elaine13.stanford.edu;myth7.stanford.edu;3
saga5.stanford.edu;myth7.stanford.edu;4
```

File: elaine20.output
Router: elaine20.stanford.edu

```
      PRINTING INITIAL TOPOLOGY
*** Router Name: elaine20.stanford.edu
--- Neighbors:
    + elaine13.stanford.edu (15)
    + saga5.stanford.edu (5)
    + epic4.stanford.edu (1)
*** Router Name: elaine13.stanford.edu
--- Neighbors:
    + elaine20.stanford.edu (15)
*** Router Name: saga5.stanford.edu
--- Neighbors:
    + elaine20.stanford.edu (5)
*** Router Name: epic4.stanford.edu
--- Neighbors:
    + elaine20.stanford.edu (1)

      PRINTING INITIAL ROUTING TABLE
elaine13.stanford.edu;elaine13.stanford.edu;15
saga5.stanford.edu;saga5.stanford.edu;5
epic4.stanford.edu;epic4.stanford.edu;1

--------------------------------------------------------------------------

       PRINTING TOPOLOGY AFTER RECEINVING LSP:
epic4.stanford.edu:(elaine20.stanford.edu;1)(myth7.stanford.edu;2)$
      FROM epic4.stanford.edu

*** Router Name: elaine20.stanford.edu
--- Neighbors:
    + elaine13.stanford.edu (15)
    + saga5.stanford.edu (5)
    + epic4.stanford.edu (1)
*** Router Name: elaine13.stanford.edu
--- Neighbors:
    + elaine20.stanford.edu (15)
*** Router Name: saga5.stanford.edu
--- Neighbors:
    + elaine20.stanford.edu (5)
*** Router Name: epic4.stanford.edu
--- Neighbors:
    + elaine20.stanford.edu (1)
    + myth7.stanford.edu (2)
*** Router Name: myth7.stanford.edu
--- Neighbors:
    + epic4.stanford.edu (2)

       PRINTING ROUTING TABLE
elaine13.stanford.edu;elaine13.stanford.edu;15
saga5.stanford.edu;saga5.stanford.edu;5
epic4.stanford.edu;epic4.stanford.edu;1
myth7.stanford.edu;epic4.stanford.edu;3

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```

```
       PRINTING TOPOLOGY AFTER RECEINVING LSP:
elaine13.stanford.edu:(elaine20.stanford.edu;15)(saga5.stanford.edu;10)(
myth7.stanford.edu;1)$
      FROM elaine13.stanford.edu

*** Router Name: elaine20.stanford.edu
--- Neighbors:
    + elaine13.stanford.edu (15)
    + saga5.stanford.edu (5)
    + epic4.stanford.edu (1)
*** Router Name: elaine13.stanford.edu
--- Neighbors:
    + elaine20.stanford.edu (15)
    + saga5.stanford.edu (10)
    + myth7.stanford.edu (1)
*** Router Name: saga5.stanford.edu
--- Neighbors:
    + elaine20.stanford.edu (5)
    + elaine13.stanford.edu (10)
*** Router Name: epic4.stanford.edu
--- Neighbors:
    + elaine20.stanford.edu (1)
    + myth7.stanford.edu (2)
*** Router Name: myth7.stanford.edu
--- Neighbors:
    + epic4.stanford.edu (2)
    + elaine13.stanford.edu (1)

       PRINTING ROUTING TABLE
elaine13.stanford.edu;epic4.stanford.edu;4
saga5.stanford.edu;saga5.stanford.edu;5
epic4.stanford.edu;epic4.stanford.edu;1
myth7.stanford.edu;epic4.stanford.edu;3

------------------------------------------------------------------------

       PRINTING TOPOLOGY AFTER RECEINVING LSP:
myth7.stanford.edu:(saga5.stanford.edu;2)(elaine13.stanford.edu;1)(epic4
.stanford.edu;2)$
      FROM epic4.stanford.edu

*** Router Name: elaine20.stanford.edu
--- Neighbors:
    + elaine13.stanford.edu (15)
    + saga5.stanford.edu (5)
    + epic4.stanford.edu (1)
*** Router Name: elaine13.stanford.edu
--- Neighbors:
    + elaine20.stanford.edu (15)
    + saga5.stanford.edu (10)
    + myth7.stanford.edu (1)
*** Router Name: saga5.stanford.edu
--- Neighbors:
    + elaine20.stanford.edu (5)
    + elaine13.stanford.edu (10)
    + myth7.stanford.edu (2)
```

```
*** Router Name: epic4.stanford.edu
--- Neighbors:
    + elaine20.stanford.edu (1)
    + myth7.stanford.edu (2)
*** Router Name: myth7.stanford.edu
--- Neighbors:
    + saga5.stanford.edu (2)
    + elaine13.stanford.edu (1)
    + epic4.stanford.edu (2)

       PRINTING ROUTING TABLE
elaine13.stanford.edu;epic4.stanford.edu;4
saga5.stanford.edu;saga5.stanford.edu;5
epic4.stanford.edu;epic4.stanford.edu;1
myth7.stanford.edu;epic4.stanford.edu;3

--------------------------------------------------------------------------

       PRINTING TOPOLOGY AFTER RECEINVING LSP:
saga5.stanford.edu:(elaine20.stanford.edu;5)(elaine13.stanford.edu;10)(m
yth7.stanford.edu;2)$
      FROM saga5.stanford.edu

*** Router Name: elaine20.stanford.edu
--- Neighbors:
    + elaine13.stanford.edu (15)
    + saga5.stanford.edu (5)
    + epic4.stanford.edu (1)
*** Router Name: elaine13.stanford.edu
--- Neighbors:
    + elaine20.stanford.edu (15)
    + saga5.stanford.edu (10)
    + myth7.stanford.edu (1)
*** Router Name: saga5.stanford.edu
--- Neighbors:
    + elaine20.stanford.edu (5)
    + elaine13.stanford.edu (10)
    + myth7.stanford.edu (2)
*** Router Name: epic4.stanford.edu
--- Neighbors:
    + elaine20.stanford.edu (1)
    + myth7.stanford.edu (2)
*** Router Name: myth7.stanford.edu
--- Neighbors:
    + saga5.stanford.edu (2)
    + elaine13.stanford.edu (1)
    + epic4.stanford.edu (2)

       PRINTING ROUTING TABLE
elaine13.stanford.edu;epic4.stanford.edu;4
saga5.stanford.edu;saga5.stanford.edu;5
epic4.stanford.edu;epic4.stanford.edu;1
myth7.stanford.edu;epic4.stanford.edu;3
```

```
      THE FINAL TOPOLOGY IS:
*** Router Name: elaine20.stanford.edu
--- Neighbors:
    + elaine13.stanford.edu (15)
    + saga5.stanford.edu (5)
    + epic4.stanford.edu (1)
*** Router Name: elaine13.stanford.edu
--- Neighbors:
    + elaine20.stanford.edu (15)
    + saga5.stanford.edu (10)
    + myth7.stanford.edu (1)
*** Router Name: saga5.stanford.edu
--- Neighbors:
    + elaine20.stanford.edu (5)
    + elaine13.stanford.edu (10)
    + myth7.stanford.edu (2)
*** Router Name: epic4.stanford.edu
--- Neighbors:
    + elaine20.stanford.edu (1)
    + myth7.stanford.edu (2)
*** Router Name: myth7.stanford.edu
--- Neighbors:
    + saga5.stanford.edu (2)
    + elaine13.stanford.edu (1)
    + epic4.stanford.edu (2)


      PRINTING FINAL ROUTING TABLE
epic4.stanford.edu;epic4.stanford.edu;1
myth7.stanford.edu;epic4.stanford.edu;3
elaine13.stanford.edu;epic4.stanford.edu;4
saga5.stanford.edu;saga5.stanford.edu;5
```

File: saga5.output
Router: saga5.stanford.edu

```
      PRINTING INITIAL TOPOLOGY
*** Router Name: saga5.stanford.edu
--- Neighbors:
    + elaine20.stanford.edu (5)
    + elaine13.stanford.edu (10)
    + myth7.stanford.edu (2)
*** Router Name: elaine20.stanford.edu
--- Neighbors:
    + saga5.stanford.edu (5)
*** Router Name: elaine13.stanford.edu
--- Neighbors:
    + saga5.stanford.edu (10)
*** Router Name: myth7.stanford.edu
--- Neighbors:
    + saga5.stanford.edu (2)

      PRINTING INITIAL ROUTING TABLE
elaine20.stanford.edu;elaine20.stanford.edu;5
elaine13.stanford.edu;elaine13.stanford.edu;10
myth7.stanford.edu;myth7.stanford.edu;2

---------------------------------------------------------------------------

       PRINTING TOPOLOGY AFTER RECEINVING LSP:
myth7.stanford.edu:(saga5.stanford.edu;2)(elaine13.stanford.edu;1)(epic4
.stanford.edu;2)$
      FROM myth7.stanford.edu

*** Router Name: saga5.stanford.edu
--- Neighbors:
    + elaine20.stanford.edu (5)
    + elaine13.stanford.edu (10)
    + myth7.stanford.edu (2)
*** Router Name: elaine20.stanford.edu
--- Neighbors:
    + saga5.stanford.edu (5)
*** Router Name: elaine13.stanford.edu
--- Neighbors:
    + saga5.stanford.edu (10)
    + myth7.stanford.edu (1)
*** Router Name: myth7.stanford.edu
--- Neighbors:
    + saga5.stanford.edu (2)
    + elaine13.stanford.edu (1)
    + epic4.stanford.edu (2)
*** Router Name: epic4.stanford.edu
--- Neighbors:
    + myth7.stanford.edu (2)

       PRINTING ROUTING TABLE
elaine20.stanford.edu;elaine20.stanford.edu;5
elaine13.stanford.edu;myth7.stanford.edu;3
myth7.stanford.edu;myth7.stanford.edu;2
```

```
epic4.stanford.edu;myth7.stanford.edu;4

---------------------------------------------------------------------

       PRINTING TOPOLOGY AFTER RECEINVING LSP:
elaine20.stanford.edu:(elaine13.stanford.edu;15)(saga5.stanford.edu;5)(e
pic4.stanford.edu;1)$
      FROM elaine20.stanford.edu

*** Router Name: saga5.stanford.edu
--- Neighbors:
    + elaine20.stanford.edu (5)
    + elaine13.stanford.edu (10)
    + myth7.stanford.edu (2)
*** Router Name: elaine20.stanford.edu
--- Neighbors:
    + elaine13.stanford.edu (15)
    + saga5.stanford.edu (5)
    + epic4.stanford.edu (1)
*** Router Name: elaine13.stanford.edu
--- Neighbors:
    + saga5.stanford.edu (10)
    + myth7.stanford.edu (1)
    + elaine20.stanford.edu (15)
*** Router Name: myth7.stanford.edu
--- Neighbors:
    + saga5.stanford.edu (2)
    + elaine13.stanford.edu (1)
    + epic4.stanford.edu (2)
*** Router Name: epic4.stanford.edu
--- Neighbors:
    + myth7.stanford.edu (2)
    + elaine20.stanford.edu (1)

       PRINTING ROUTING TABLE
elaine20.stanford.edu;elaine20.stanford.edu;5
elaine13.stanford.edu;myth7.stanford.edu;3
myth7.stanford.edu;myth7.stanford.edu;2
epic4.stanford.edu;myth7.stanford.edu;4

---------------------------------------------------------------------

       PRINTING TOPOLOGY AFTER RECEINVING LSP:
elaine13.stanford.edu:(elaine20.stanford.edu;15)(saga5.stanford.edu;10)(
myth7.stanford.edu;1)$
      FROM elaine13.stanford.edu

*** Router Name: saga5.stanford.edu
--- Neighbors:
    + elaine20.stanford.edu (5)
    + elaine13.stanford.edu (10)
    + myth7.stanford.edu (2)
*** Router Name: elaine20.stanford.edu
--- Neighbors:
    + elaine13.stanford.edu (15)
    + saga5.stanford.edu (5)
    + epic4.stanford.edu (1)
```

```
*** Router Name: elaine13.stanford.edu
--- Neighbors:
    + elaine20.stanford.edu (15)
    + saga5.stanford.edu (10)
    + myth7.stanford.edu (1)
*** Router Name: myth7.stanford.edu
--- Neighbors:
    + saga5.stanford.edu (2)
    + elaine13.stanford.edu (1)
    + epic4.stanford.edu (2)
*** Router Name: epic4.stanford.edu
--- Neighbors:
    + myth7.stanford.edu (2)
    + elaine20.stanford.edu (1)

       PRINTING ROUTING TABLE
elaine20.stanford.edu;elaine20.stanford.edu;5
elaine13.stanford.edu;myth7.stanford.edu;3
myth7.stanford.edu;myth7.stanford.edu;2
epic4.stanford.edu;myth7.stanford.edu;4

------------------------------------------------------------------------

       PRINTING TOPOLOGY AFTER RECEINVING LSP:
epic4.stanford.edu:(elaine20.stanford.edu;1)(myth7.stanford.edu;2)$
      FROM myth7.stanford.edu

*** Router Name: saga5.stanford.edu
--- Neighbors:
    + elaine20.stanford.edu (5)
    + elaine13.stanford.edu (10)
    + myth7.stanford.edu (2)
*** Router Name: elaine20.stanford.edu
--- Neighbors:
    + elaine13.stanford.edu (15)
    + saga5.stanford.edu (5)
    + epic4.stanford.edu (1)
*** Router Name: elaine13.stanford.edu
--- Neighbors:
    + elaine20.stanford.edu (15)
    + saga5.stanford.edu (10)
    + myth7.stanford.edu (1)
*** Router Name: myth7.stanford.edu
--- Neighbors:
    + saga5.stanford.edu (2)
    + elaine13.stanford.edu (1)
    + epic4.stanford.edu (2)
*** Router Name: epic4.stanford.edu
--- Neighbors:
    + elaine20.stanford.edu (1)
    + myth7.stanford.edu (2)

       PRINTING ROUTING TABLE
elaine20.stanford.edu;elaine20.stanford.edu;5
elaine13.stanford.edu;myth7.stanford.edu;3
myth7.stanford.edu;myth7.stanford.edu;2
epic4.stanford.edu;myth7.stanford.edu;4
```

```
--------------------------------------------------------------------------
      THE FINAL TOPOLOGY IS:
*** Router Name: saga5.stanford.edu
--- Neighbors:
    + elaine20.stanford.edu (5)
    + elaine13.stanford.edu (10)
    + myth7.stanford.edu (2)
*** Router Name: elaine20.stanford.edu
--- Neighbors:
    + elaine13.stanford.edu (15)
    + saga5.stanford.edu (5)
    + epic4.stanford.edu (1)
*** Router Name: elaine13.stanford.edu
--- Neighbors:
    + elaine20.stanford.edu (15)
    + saga5.stanford.edu (10)
    + myth7.stanford.edu (1)
*** Router Name: myth7.stanford.edu
--- Neighbors:
    + saga5.stanford.edu (2)
    + elaine13.stanford.edu (1)
    + epic4.stanford.edu (2)
*** Router Name: epic4.stanford.edu
--- Neighbors:
    + elaine20.stanford.edu (1)
    + myth7.stanford.edu (2)


      PRINTING FINAL ROUTING TABLE
myth7.stanford.edu;myth7.stanford.edu;2
elaine13.stanford.edu;myth7.stanford.edu;3
epic4.stanford.edu;myth7.stanford.edu;4
elaine20.stanford.edu;elaine20.stanford.edu;5
```

File: myth7.output
Router: myth7.stanford.edu

```
      PRINTING INITIAL TOPOLOGY
*** Router Name: myth7.stanford.edu
--- Neighbors:
    + saga5.stanford.edu (2)
    + elaine13.stanford.edu (1)
    + epic4.stanford.edu (2)
*** Router Name: saga5.stanford.edu
--- Neighbors:
    + myth7.stanford.edu (2)
*** Router Name: elaine13.stanford.edu
--- Neighbors:
    + myth7.stanford.edu (1)
*** Router Name: epic4.stanford.edu
--- Neighbors:
    + myth7.stanford.edu (2)

      PRINTING INITIAL ROUTING TABLE
saga5.stanford.edu;saga5.stanford.edu;2
elaine13.stanford.edu;elaine13.stanford.edu;1
epic4.stanford.edu;epic4.stanford.edu;2

--------------------------------------------------------------------------

       PRINTING TOPOLOGY AFTER RECEINVING LSP:
epic4.stanford.edu:(elaine20.stanford.edu;1)(myth7.stanford.edu;2)$
      FROM epic4.stanford.edu

*** Router Name: myth7.stanford.edu
--- Neighbors:
    + saga5.stanford.edu (2)
    + elaine13.stanford.edu (1)
    + epic4.stanford.edu (2)
*** Router Name: saga5.stanford.edu
--- Neighbors:
    + myth7.stanford.edu (2)
*** Router Name: elaine13.stanford.edu
--- Neighbors:
    + myth7.stanford.edu (1)
*** Router Name: epic4.stanford.edu
--- Neighbors:
    + elaine20.stanford.edu (1)
    + myth7.stanford.edu (2)
*** Router Name: elaine20.stanford.edu
--- Neighbors:
    + epic4.stanford.edu (1)

       PRINTING ROUTING TABLE
saga5.stanford.edu;saga5.stanford.edu;2
elaine13.stanford.edu;elaine13.stanford.edu;1
epic4.stanford.edu;epic4.stanford.edu;2
elaine20.stanford.edu;epic4.stanford.edu;3

--------------------------------------------------------------------------
```

```
       PRINTING TOPOLOGY AFTER RECEINVING LSP:
elaine13.stanford.edu:(elaine20.stanford.edu;15)(saga5.stanford.edu;10)(
myth7.stanford.edu;1)$
      FROM elaine13.stanford.edu

*** Router Name: myth7.stanford.edu
--- Neighbors:
    + saga5.stanford.edu (2)
    + elaine13.stanford.edu (1)
    + epic4.stanford.edu (2)
*** Router Name: saga5.stanford.edu
--- Neighbors:
    + myth7.stanford.edu (2)
    + elaine13.stanford.edu (10)
*** Router Name: elaine13.stanford.edu
--- Neighbors:
    + elaine20.stanford.edu (15)
    + saga5.stanford.edu (10)
    + myth7.stanford.edu (1)
*** Router Name: epic4.stanford.edu
--- Neighbors:
    + elaine20.stanford.edu (1)
    + myth7.stanford.edu (2)
*** Router Name: elaine20.stanford.edu
--- Neighbors:
    + epic4.stanford.edu (1)
    + elaine13.stanford.edu (15)

       PRINTING ROUTING TABLE
saga5.stanford.edu;saga5.stanford.edu;2
elaine13.stanford.edu;elaine13.stanford.edu;1
epic4.stanford.edu;epic4.stanford.edu;2
elaine20.stanford.edu;epic4.stanford.edu;3

------------------------------------------------------------------------

       PRINTING TOPOLOGY AFTER RECEINVING LSP:
elaine20.stanford.edu:(elaine13.stanford.edu;15)(saga5.stanford.edu;5)(e
pic4.stanford.edu;1)$
      FROM epic4.stanford.edu

*** Router Name: myth7.stanford.edu
--- Neighbors:
    + saga5.stanford.edu (2)
    + elaine13.stanford.edu (1)
    + epic4.stanford.edu (2)
*** Router Name: saga5.stanford.edu
--- Neighbors:
    + myth7.stanford.edu (2)
    + elaine13.stanford.edu (10)
    + elaine20.stanford.edu (5)
*** Router Name: elaine13.stanford.edu
--- Neighbors:
    + elaine20.stanford.edu (15)
    + saga5.stanford.edu (10)
    + myth7.stanford.edu (1)
```

```
*** Router Name: epic4.stanford.edu
--- Neighbors:
    + elaine20.stanford.edu (1)
    + myth7.stanford.edu (2)
*** Router Name: elaine20.stanford.edu
--- Neighbors:
    + elaine13.stanford.edu (15)
    + saga5.stanford.edu (5)
    + epic4.stanford.edu (1)

       PRINTING ROUTING TABLE
saga5.stanford.edu;saga5.stanford.edu;2
elaine13.stanford.edu;elaine13.stanford.edu;1
epic4.stanford.edu;epic4.stanford.edu;2
elaine20.stanford.edu;epic4.stanford.edu;3

---------------------------------------------------------------------

       PRINTING TOPOLOGY AFTER RECEINVING LSP:
saga5.stanford.edu:(elaine20.stanford.edu;5)(elaine13.stanford.edu;10)(m
yth7.stanford.edu;2)$
      FROM saga5.stanford.edu

*** Router Name: myth7.stanford.edu
--- Neighbors:
    + saga5.stanford.edu (2)
    + elaine13.stanford.edu (1)
    + epic4.stanford.edu (2)
*** Router Name: saga5.stanford.edu
--- Neighbors:
    + elaine20.stanford.edu (5)
    + elaine13.stanford.edu (10)
    + myth7.stanford.edu (2)
*** Router Name: elaine13.stanford.edu
--- Neighbors:
    + elaine20.stanford.edu (15)
    + saga5.stanford.edu (10)
    + myth7.stanford.edu (1)
*** Router Name: epic4.stanford.edu
--- Neighbors:
    + elaine20.stanford.edu (1)
    + myth7.stanford.edu (2)
*** Router Name: elaine20.stanford.edu
--- Neighbors:
    + elaine13.stanford.edu (15)
    + saga5.stanford.edu (5)
    + epic4.stanford.edu (1)

       PRINTING ROUTING TABLE
saga5.stanford.edu;saga5.stanford.edu;2
elaine13.stanford.edu;elaine13.stanford.edu;1
epic4.stanford.edu;epic4.stanford.edu;2
elaine20.stanford.edu;epic4.stanford.edu;3
```

```
      THE FINAL TOPOLOGY IS:
*** Router Name: myth7.stanford.edu
--- Neighbors:
    + saga5.stanford.edu (2)
    + elaine13.stanford.edu (1)
    + epic4.stanford.edu (2)
*** Router Name: saga5.stanford.edu
--- Neighbors:
    + elaine20.stanford.edu (5)
    + elaine13.stanford.edu (10)
    + myth7.stanford.edu (2)
*** Router Name: elaine13.stanford.edu
--- Neighbors:
    + elaine20.stanford.edu (15)
    + saga5.stanford.edu (10)
    + myth7.stanford.edu (1)
*** Router Name: epic4.stanford.edu
--- Neighbors:
    + elaine20.stanford.edu (1)
    + myth7.stanford.edu (2)
*** Router Name: elaine20.stanford.edu
--- Neighbors:
    + elaine13.stanford.edu (15)
    + saga5.stanford.edu (5)
    + epic4.stanford.edu (1)


      PRINTING FINAL ROUTING TABLE
elaine13.stanford.edu;elaine13.stanford.edu;1
epic4.stanford.edu;epic4.stanford.edu;2
saga5.stanford.edu;saga5.stanford.edu;2
elaine20.stanford.edu;epic4.stanford.edu;3
```

File: elaine13.output
Router: elaine13.stanford.edu

```
      PRINTING INITIAL TOPOLOGY
*** Router Name: elaine13.stanford.edu
--- Neighbors:
    + elaine20.stanford.edu (15)
    + saga5.stanford.edu (10)
    + myth7.stanford.edu (1)
*** Router Name: elaine20.stanford.edu
--- Neighbors:
    + elaine13.stanford.edu (15)
*** Router Name: saga5.stanford.edu
--- Neighbors:
    + elaine13.stanford.edu (10)
*** Router Name: myth7.stanford.edu
--- Neighbors:
    + elaine13.stanford.edu (1)

      PRINTING INITIAL ROUTING TABLE
elaine20.stanford.edu;elaine20.stanford.edu;15
saga5.stanford.edu;saga5.stanford.edu;10
myth7.stanford.edu;myth7.stanford.edu;1

--------------------------------------------------------------------------

       PRINTING TOPOLOGY AFTER RECEINVING LSP:
myth7.stanford.edu:(saga5.stanford.edu;2)(elaine13.stanford.edu;1)(epic4
.stanford.edu;2)$
      FROM myth7.stanford.edu

*** Router Name: elaine13.stanford.edu
--- Neighbors:
    + elaine20.stanford.edu (15)
    + saga5.stanford.edu (10)
    + myth7.stanford.edu (1)
*** Router Name: elaine20.stanford.edu
--- Neighbors:
    + elaine13.stanford.edu (15)
*** Router Name: saga5.stanford.edu
--- Neighbors:
    + elaine13.stanford.edu (10)
    + myth7.stanford.edu (2)
*** Router Name: myth7.stanford.edu
--- Neighbors:
    + saga5.stanford.edu (2)
    + elaine13.stanford.edu (1)
    + epic4.stanford.edu (2)
*** Router Name: epic4.stanford.edu
--- Neighbors:
    + myth7.stanford.edu (2)

       PRINTING ROUTING TABLE
elaine20.stanford.edu;elaine20.stanford.edu;15
saga5.stanford.edu;myth7.stanford.edu;3
myth7.stanford.edu;myth7.stanford.edu;1
```

```
epic4.stanford.edu;myth7.stanford.edu;3

------------------------------------------------------------------------

       PRINTING TOPOLOGY AFTER RECEINVING LSP:
elaine20.stanford.edu:(elaine13.stanford.edu;15)(saga5.stanford.edu;5)(e
pic4.stanford.edu;1)$
      FROM elaine20.stanford.edu

*** Router Name: elaine13.stanford.edu
--- Neighbors:
    + elaine20.stanford.edu (15)
    + saga5.stanford.edu (10)
    + myth7.stanford.edu (1)
*** Router Name: elaine20.stanford.edu
--- Neighbors:
    + elaine13.stanford.edu (15)
    + saga5.stanford.edu (5)
    + epic4.stanford.edu (1)
*** Router Name: saga5.stanford.edu
--- Neighbors:
    + elaine13.stanford.edu (10)
    + myth7.stanford.edu (2)
    + elaine20.stanford.edu (5)
*** Router Name: myth7.stanford.edu
--- Neighbors:
    + saga5.stanford.edu (2)
    + elaine13.stanford.edu (1)
    + epic4.stanford.edu (2)
*** Router Name: epic4.stanford.edu
--- Neighbors:
    + myth7.stanford.edu (2)
    + elaine20.stanford.edu (1)

       PRINTING ROUTING TABLE
elaine20.stanford.edu;myth7.stanford.edu;4
saga5.stanford.edu;myth7.stanford.edu;3
myth7.stanford.edu;myth7.stanford.edu;1
epic4.stanford.edu;myth7.stanford.edu;3

------------------------------------------------------------------------

       PRINTING TOPOLOGY AFTER RECEINVING LSP:
epic4.stanford.edu:(elaine20.stanford.edu;1)(myth7.stanford.edu;2)$
      FROM myth7.stanford.edu

*** Router Name: elaine13.stanford.edu
--- Neighbors:
    + elaine20.stanford.edu (15)
    + saga5.stanford.edu (10)
    + myth7.stanford.edu (1)
*** Router Name: elaine20.stanford.edu
--- Neighbors:
    + elaine13.stanford.edu (15)
    + saga5.stanford.edu (5)
    + epic4.stanford.edu (1)
*** Router Name: saga5.stanford.edu
```

```
--- Neighbors:
    + elaine13.stanford.edu (10)
    + myth7.stanford.edu (2)
    + elaine20.stanford.edu (5)
*** Router Name: myth7.stanford.edu
--- Neighbors:
    + saga5.stanford.edu (2)
    + elaine13.stanford.edu (1)
    + epic4.stanford.edu (2)
*** Router Name: epic4.stanford.edu
--- Neighbors:
    + elaine20.stanford.edu (1)
    + myth7.stanford.edu (2)

       PRINTING ROUTING TABLE
elaine20.stanford.edu;myth7.stanford.edu;4
saga5.stanford.edu;myth7.stanford.edu;3
myth7.stanford.edu;myth7.stanford.edu;1
epic4.stanford.edu;myth7.stanford.edu;3

------------------------------------------------------------------------

       PRINTING TOPOLOGY AFTER RECEINVING LSP:
saga5.stanford.edu:(elaine20.stanford.edu;5)(elaine13.stanford.edu;10)(m
yth7.stanford.edu;2)$
      FROM saga5.stanford.edu

*** Router Name: elaine13.stanford.edu
--- Neighbors:
    + elaine20.stanford.edu (15)
    + saga5.stanford.edu (10)
    + myth7.stanford.edu (1)
*** Router Name: elaine20.stanford.edu
--- Neighbors:
    + elaine13.stanford.edu (15)
    + saga5.stanford.edu (5)
    + epic4.stanford.edu (1)
*** Router Name: saga5.stanford.edu
--- Neighbors:
    + elaine20.stanford.edu (5)
    + elaine13.stanford.edu (10)
    + myth7.stanford.edu (2)
*** Router Name: myth7.stanford.edu
--- Neighbors:
    + saga5.stanford.edu (2)
    + elaine13.stanford.edu (1)
    + epic4.stanford.edu (2)
*** Router Name: epic4.stanford.edu
--- Neighbors:
    + elaine20.stanford.edu (1)
    + myth7.stanford.edu (2)

       PRINTING ROUTING TABLE
elaine20.stanford.edu;myth7.stanford.edu;4
saga5.stanford.edu;myth7.stanford.edu;3
myth7.stanford.edu;myth7.stanford.edu;1
epic4.stanford.edu;myth7.stanford.edu;3
```

```
--------------------------------------------------------------------------
      THE FINAL TOPOLOGY IS:
*** Router Name: elaine13.stanford.edu
--- Neighbors:
    + elaine20.stanford.edu (15)
    + saga5.stanford.edu (10)
    + myth7.stanford.edu (1)
*** Router Name: elaine20.stanford.edu
--- Neighbors:
    + elaine13.stanford.edu (15)
    + saga5.stanford.edu (5)
    + epic4.stanford.edu (1)
*** Router Name: saga5.stanford.edu
--- Neighbors:
    + elaine20.stanford.edu (5)
    + elaine13.stanford.edu (10)
    + myth7.stanford.edu (2)
*** Router Name: myth7.stanford.edu
--- Neighbors:
    + saga5.stanford.edu (2)
    + elaine13.stanford.edu (1)
    + epic4.stanford.edu (2)
*** Router Name: epic4.stanford.edu
--- Neighbors:
    + elaine20.stanford.edu (1)
    + myth7.stanford.edu (2)


      PRINTING FINAL ROUTING TABLE
myth7.stanford.edu;myth7.stanford.edu;1
epic4.stanford.edu;myth7.stanford.edu;3
saga5.stanford.edu;myth7.stanford.edu;3
elaine20.stanford.edu;myth7.stanford.edu;4
```