CS3205 Computer Networks Lab 4 Report

(Jan - May 2021 - Prof. Siva Ram Murthy)

Assignment 3: **OSPF Routing Algorithm**

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Aim

The purpose of this assignment is to implement a simplified version of the OSPF routing protocol. We will implement Dijstra's Algorithm (SSSP) to compute shortest path links from a source to all the nodes (here routers).

Introduction

End systems consist of devices connected to routers using switches. Routers are the networking device which carries packets from one network to another. This communication between routers happens in the networking layer across links and is called **Internet routing**.

The Internet routing is based on the AS concept (Autonomous systems). An AS (also known as routing domain) is a region of network under a single administrative domain. It has a collection of routers within an administration. There are two types of routing protocols:

1. Interior Gateway Protocols (IGP): Also called Intra-domain routing protocol or Intra-AS routing. It is used for routing within the autonomous system. Companies and organizations use IGP on their internal networks. Examples include RIP (Routing Information Protocol), OSPF (Open Shortest Path First) routing protocol, etc.
2. Exterior Gateway Protocols (EGP): Also called Inter-AS routing. It is used for routing between autonomous systems. Service providers and large companies interact using EGP. Example of EGP is Border Gateway Protocol (BGP) which is used by the Internet.

We will consider OSPF routing protocol and achieve a limited form of intra-AS routing. This protocol focuses on finding the shortest path possible between two routers. It uses Dijstra's algorithm (SSSP) to determine the shortest paths. To perform this algorithm, first every router needs to get an outline of the complete network topology. One of the ways to do this is using **flooding** which advertises the link state of each router to all its neighbours and they propagate it further.

OSPF Algorithm

OSPF routing protocol consists of three phases happening in parallel:

A) Exchange HELLO packets: Each server sends HELLO packets and simultaneously receives it. After receiving the packet, it sends pack HELLOREPLY packet which also consists of the link cost (edge) in communicating between these two neighbours. During runtime, link cost continuously keeps varying hence this exchange happens in a regular interval of time.

B) Link State Protocol or Link State Advertisement (LSP/LSA): Each router or node has information about only its neighbour edges. But it needs all the edge weights (complete topology), hence it performs link state advertisement. As all the edge weights keep changing, the LSP also keeps happening in regular intervals and updates the topology.

C) Find shortest path: Now that the topology which consists of a graph is found, we perform shortest path algorithm at each router for it knows the best route to any of the nodes in the system. We will use Dijstra's Single Source Shortest Path (SSSP) algorithm. As all the edges are updating continuously, this algorithm is also repeated in a regular interval of time.

Implementation details

Main function: The main program extracts the arguments, parses the input file and creates the basic neighbour topology along with the range of edge weights we can have. Next it uses four threads to perform the three steps of the OSPF algorithm. The first one is used to independently receive any message from the rest of the servers. The other three are used to send HELLO packets until acknowledgement, send LSA messages and perform Dijstra's algorithm. The main thread later sleeps for 65 seconds. So the Dijstra's algorithm works around 3 times for all the servers if Z = 20 (default).

The main function takes 6 arguments which are:

argv	name	details
1	id	Router id for which the routing table will be made
2	inputFile	The input file which has all the edges and range of edge weights
3	outputFile	The output file where the routing table will be appended after every Z seconds
4	X	Time interval for performing step A of OSPF algorithm
5	Y	Time interval for performing step B of OSPF algorithm
6	Z	Time interval for performing step C of OSPF algorithm

It forms the array of server class and updates the neighbors and edge weights lengths. Next it invokes 4 threads executing concurrently.

Server structure: I maintained a class for all the nodes along the root node which is the router itself. This structure stores private and public data required by the main program. It stores the socket details, all the corresponding neighbours from the input file, the range of edge weights for each neighbour and the edge weights. I have added some getter and setter functions and their details are mentioned above each function declaration.

The executable ospf is invoked for all the routers concurrently. All of them behave as servers and clients simultaneously.

Observations and Results

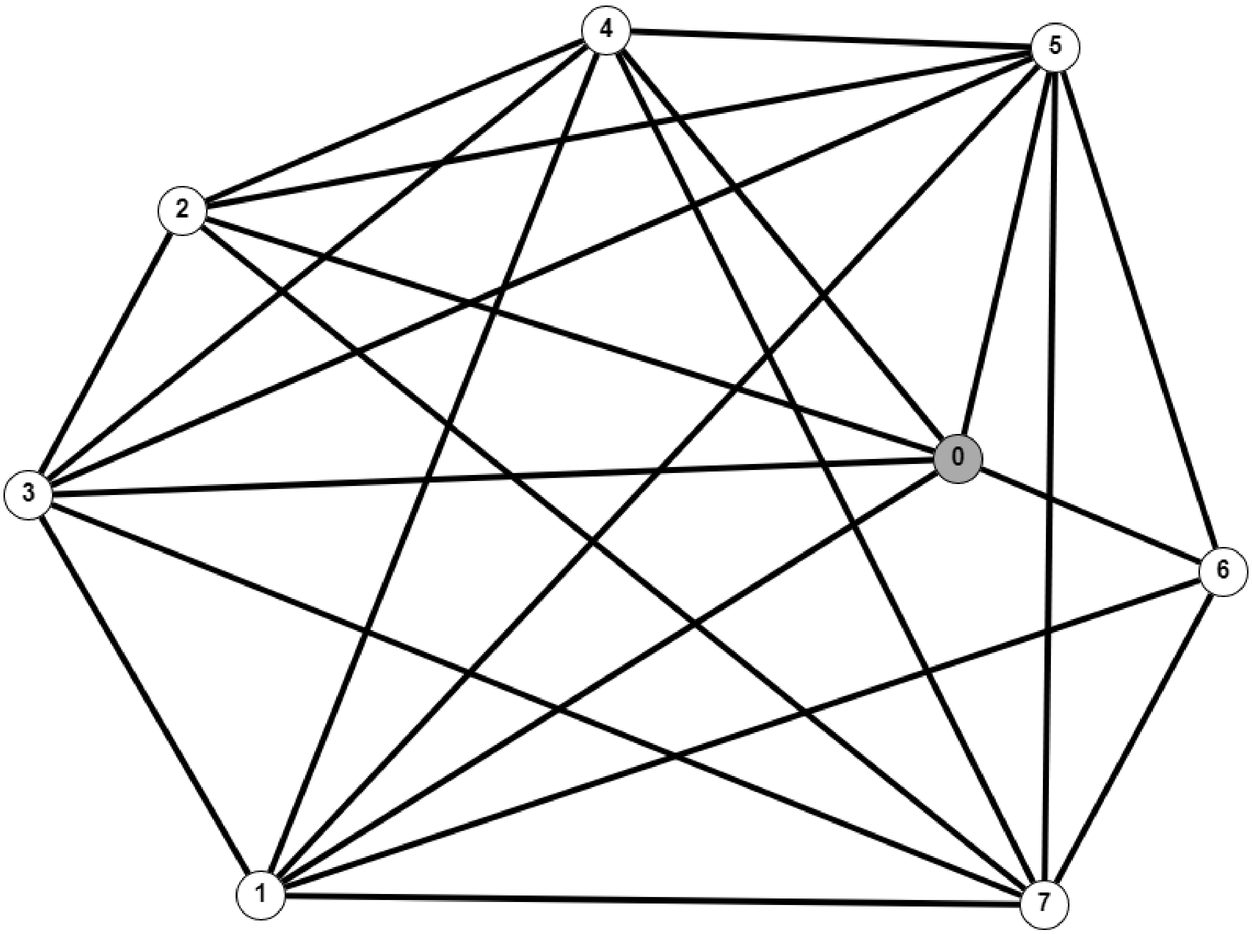
The main thread runs for 65 seconds. Hence Dijstra's algorithm works for around 3 times for every server if Z = 20 (default).

The two input topologies used in the program were the following:

input1.txt

```
8 23
0 1 2 10
0 2 4 15
0 3 6 7
0 4 3 10
0 5 2 11
0 6 9 11
1 3 10 12
1 4 7 10
1 5 9 13
1 6 7 12
1 7 7 21
2 3 8 19
2 4 13 15
2 5 1 4
2 7 10 11
3 4 3 4
3 5 11 11
3 7 1 20
4 5 11 15
4 7 10 19
5 6 1 2
```

```
5 7 9 19
6 7 10 25
```



After running the script, the output files contain:

outputOSPF0.txt

```
Routing Table for Node No. 0 at Time 0
Destination     Path     Cost
     0           0          0
     1           01         8
     2           052        4
     3           03         6
     4           04         4
     5           05         3
     6           056        4
     7           057        12

Routing Table for Node No. 0 at Time 20
Destination     Path     Cost
```

```
    0          0          0
    1          01         8
    2          052         4
    3          03         6
    4          04         4
    5          05         3
    6          056         4
    7          057        12
```

```
Routing Table for Node No. 0 at Time 40
Destination     Path     Cost
    0          0          0
    1          01         8
    2          052         4
    3          03         6
    4          04         4
    5          05         3
    6          056         4
    7          057        12
```

outputOSPF1.txt

```
Routing Table for Node No. 1 at Time 0
Destination     Path     Cost
    0          10         8
    1          1          0
    2          1052       12
    3          143        11
    4          14         8
    5          105        11
    6          16         10
    7          17         10
```

```
Routing Table for Node No. 1 at Time 20
Destination     Path     Cost
    0          10         8
    1          1          0
    2          1052       12
    3          143        11
    4          14         8
    5          105        11
    6          16         10
    7          17         10
```

```
Routing Table for Node No. 1 at Time 40
```

```
Destination    Path    Cost
    0          10       8
    1          1        0
    2          1052      12
    3          143      11
    4          14       8
    5          105      11
    6          16       10
    7          17       10
```

outputOSPF2.txt

```
Routing Table for Node No. 2 at Time 0
Destination    Path    Cost
    0          250      4
    1          251      11
    2          2        0
    3          23       9
    4          2504      8
    5          25       2
    6          256      3
    7          27       10

Routing Table for Node No. 2 at Time 20
Destination    Path    Cost
    0          250      4
    1          251      11
    2          2        0
    3          2503      10
    4          2504      8
    5          25       2
    6          256      3
    7          27       10

Routing Table for Node No. 2 at Time 40
Destination    Path    Cost
    0          250      4
    1          251      11
    2          2        0
    3          2503      10
    4          2504      8
    5          25       2
    6          256      3
    7          27       10
```

outputOSPF3.txt

```
Routing Table for Node No. 3 at Time 0
Destination   Path   Cost
   0       30      6
   1       301      14
   2       32      9
   3       3      0
   4       34      3
   5       305      9
   6       3056      10
   7       37      9

Routing Table for Node No. 3 at Time 20
Destination   Path   Cost
   0       30      6
   1       301      14
   2       32      9
   3       3      0
   4       34      3
   5       305      9
   6       3056      10
   7       37      9

Routing Table for Node No. 3 at Time 40
Destination   Path   Cost
   0       30      6
   1       301      14
   2       32      9
   3       3      0
   4       34      3
   5       305      9
   6       3056      10
   7       37      9
```

outputOSPF4.txt

```
Routing Table for Node No. 4 at Time 0
Destination   Path   Cost
   0       40      4
   1       401      12
   2       4052      8
   3       43      3
   4       4      0
   5       405      7
   6       4056      8
   7         437        12

Routing Table for Node No. 4 at Time 20
Destination     Path     Cost
   0         40         4
   1         401        12
   2         4052       8
   3         43         3
   4         4          0
   5         405        7
   6         4056       8
   7         437        12

Routing Table for Node No. 4 at Time 40
Destination     Path     Cost
   0         40         4
   1         401        12
   2         4052       8
   3         43         3
   4         4          0
   5         405        7
   6         4056       8
   7         437        12
```

outputOSPF5.txt

```
Routing Table for Node No. 5 at Time 0
Destination     Path     Cost
   0         50         3
   1         51         9
   2         52         2
   3         503        9
   4         504        7
   5         5          0
   6         56         1
   7         57         12

Routing Table for Node No. 5 at Time 20
Destination     Path     Cost
   0         50         3
   1         51         9
   2         52         3
   3         503        9
   4         504        7
   5         5          0
   6       56       1
   7       57       12

Routing Table for Node No. 5 at Time 40
Destination   Path   Cost
   0       50       3
   1       51       9
   2       52       2
   3       503       9
   4       504       7
   5       5       0
   6       56       2
   7       57       12
```

outputOSPF6.txt

```
Routing Table for Node No. 6 at Time 0
Destination   Path   Cost
   0       650       3
   1       61       10
   2       652       2
   3       6503       9
   4       6504       7
   5       65       1
   6       6       0
   7       657       10

Routing Table for Node No. 6 at Time 20
Destination   Path   Cost
   0       650       3
   1       61       10
   2       652       2
   3       6503       9
   4       6504       7
   5       65       1
   6       6       0
   7       657       10

Routing Table for Node No. 6 at Time 40
Destination   Path   Cost
   0       650       3
   1       61       10
   2       652       2
   3       6503       9
   4       6504       7
```

```
    5          65         1
    6          6          0
    7          657        10
```

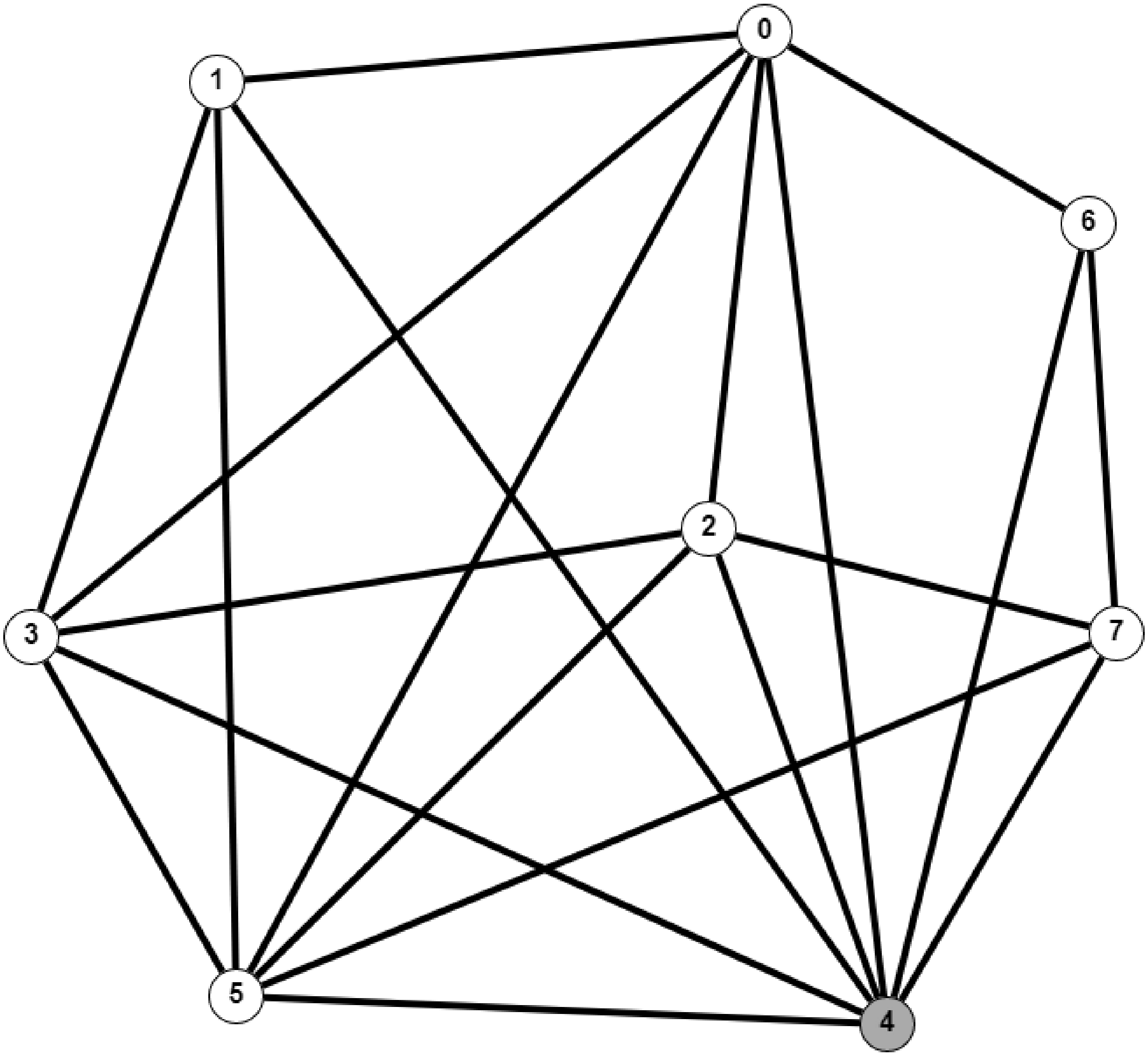
outputOSPF7.txt

```
Routing Table for Node No. 7 at Time 0
Destination     Path     Cost
    0          750        14
    1          71         10
    2          72         10
    3          73         9
    4          734        12
    5          75         12
    6          76         12
    7          7          0

Routing Table for Node No. 7 at Time 20
Destination     Path     Cost
    0          750        14
    1          71         10
    2          72         10
    3          73         9
    4          734        12
    5          75         12
    6          756        13
    7          7          0

Routing Table for Node No. 7 at Time 40
Destination     Path     Cost
    0          750        14
    1          71         10
    2          72         10
    3          73         9
    4          734        12
    5          75         12
    6          76         12
    7          7          0
```

input2.txt

```
8 20
0 1 2 10
0 2 4 15
```

```
0 3 6 7
0 4 3 10
0 5 2 11
1 3 10 12
1 4 7 10
1 5 9 13
2 3 8 19
2 4 13 15
2 5 1 4
3 4 3 4
3 5 11 11
4 5 11 15
6 0 10 15
6 4 2 10
6 7 19 20
7 2 5 7
7 4 8 10
7 5 23 25
```



After running the script, the output files contain:

outputOSPF0.txt

```
Routing Table for Node No. 0 at Time 0
Destination     Path     Cost
     0           0          0
     1           01         8
     2           052        4
     3           03         6
     4           04         4
     5           05         3
     6           06         12
     7           0527       10
```

```
Routing Table for Node No. 0 at Time 20
Destination     Path     Cost
     0          0         0
     1          01        8
     2          052        4
     3          03        6
     4          04        4
     5          05        3
     6          06        12
     7          0527       10

Routing Table for Node No. 0 at Time 40
Destination     Path     Cost
     0          0         0
     1          01        8
     2          052        4
     3          03        6
     4          04        4
     5          05        3
     6          06        12
     7          0527       10
```

outputOSPF1.txt

```
Routing Table for Node No. 1 at Time 0
Destination     Path     Cost
     0          10        8
     1          1         0
     2          152        10
     3          13        10
     4          14        7
     5          15        9
     6          146        15
     7          147        15

Routing Table for Node No. 1 at Time 20
Destination     Path     Cost
     0          10        8
     1          1         0
     2          152        10
     3          143        10
     4          14        7
     5          15        9
     6          146        15
```

```
    7          147        15

Routing Table for Node No. 1 at Time 40
Destination     Path     Cost
    0          10         8
    1          1         0
    2          152        10
    3          143        10
    4          14         7
    5          15         9
    6          146        15
    7          147        15
```

outputOSPF2.txt

```
Routing Table for Node No. 2 at Time 0
Destination     Path     Cost
    0          250        3
    1          251        10
    2          2         0
    3          2503       9
    4          2504       7
    5          25         1
    6          2506       15
    7          27         6

Routing Table for Node No. 2 at Time 20
Destination     Path     Cost
    0          250        3
    1          251        10
    2          2         0
    3          2503       9
    4          2504       7
    5          25         1
    6          2506       15
    7          27         6

Routing Table for Node No. 2 at Time 40
Destination     Path     Cost
    0          250        3
    1          251        10
    2          2         0
    3          2503       9
    4          2504       7
    5          25         1
    6          2506       15
    7          27         6
```

outputOSPF3.txt

```
Routing Table for Node No. 3 at Time 0
Destination     Path     Cost
    0          30         6
    1          31         10
    2          3052       10
    3          3         0
    4          34         3
    5          305        9
    6          346        11
    7          347        11

Routing Table for Node No. 3 at Time 20
Destination     Path     Cost
    0          30         6
    1          31         10
    2          3052       10
    3          3         0
    4          34         3
    5          305        9
    6          346        11
    7          347        11

Routing Table for Node No. 3 at Time 40
Destination     Path     Cost
    0          30         6
    1          31         10
    2          3052       10
    3          3         0
    4          34         3
    5          305        9
    6          346        11
    7          347        11
```

outputOSPF4.txt

```
Routing Table for Node No. 4 at Time 0
Destination     Path     Cost
    0          40         4
    1          41         7
    2          4052       8
    3          43         3
    4          4          0
    5          405        7
    6          46         8
    7          47         8

Routing Table for Node No. 4 at Time 20
Destination     Path     Cost
    0          40         4
    1          41         7
    2          4052       8
    3          43         3
    4          4          0
    5          405        7
    6          46         8
    7          47         8

Routing Table for Node No. 4 at Time 40
Destination     Path     Cost
    0          40         4
    1          41         7
    2          4052       8
    3          43         3
    4          4          0
    5          405        7
    6          46         8
    7          47         8
```

outputOSPF5.txt

```
Routing Table for Node No. 5 at Time 0
Destination     Path     Cost
    0          50         3
    1          51         9
    2          52         1
    3          503        9
    4          504        7
    5          5          0
    6          506        15
    7          5047       15

Routing Table for Node No. 5 at Time 20
Destination     Path     Cost
    0          50         3
    1          51         9
    2          52         1
    3          503        9
    4          504        7
    5          5          0
    6          506        15
    7          5047       15

Routing Table for Node No. 5 at Time 40
Destination     Path     Cost
    0          50         3
    1          51         9
    2          52         1
    3          503        9
    4          504        7
    5          5          0
    6          506        15
    7          5047       15
```

outputOSPF6.txt

```
Routing Table for Node No. 6 at Time 0
Destination     Path     Cost
    0          60         12
    1          641        15
    2          6052       16
    3          643        11
    4          64         8
    5          605        15
    6          6          0
    7          647        16

Routing Table for Node No. 6 at Time 20
Destination     Path     Cost
    0          60         12
    1          641        15
    2          6052       16
    3          643        11
    4          64         8
    5          605        15
    6          6          0
    7          647        16

Routing Table for Node No. 6 at Time 40
Destination     Path     Cost
    0          60         12
    1          641        15
    2         6052      16
    3         643       11
    4         64        8
    5         605       15
    6         6         0
    7         647       16
```

outputOSPF7.txt

```
Routing Table for Node No. 7 at Time 0
Destination     Path     Cost
    0         740       12
    1         741       15
    2         74052      16
    3         743       11
    4         74        8
    5         7405      15
    6         746       16
    7         7         0

Routing Table for Node No. 7 at Time 20
Destination     Path     Cost
    0         740       12
    1         741       15
    2         74052      16
    3         743       11
    4         74        8
    5         7405      15
    6         746       16
    7         7         0

Routing Table for Node No. 7 at Time 40
Destination     Path     Cost
    0         740       12
    1         741       15
    2         74052      16
    3         743       11
    4         74        8
    5         7405      15
    6         746       16
    7         7         0
```

Conclusions

The OSPF algorithm runned successfully across the routers. As the messages sent are UDP packets we don’t have any feedback mechanism for LSA and HELLOREPLY message. Also we haven’t considered time to live in the implementation for the simplicity of assignment.