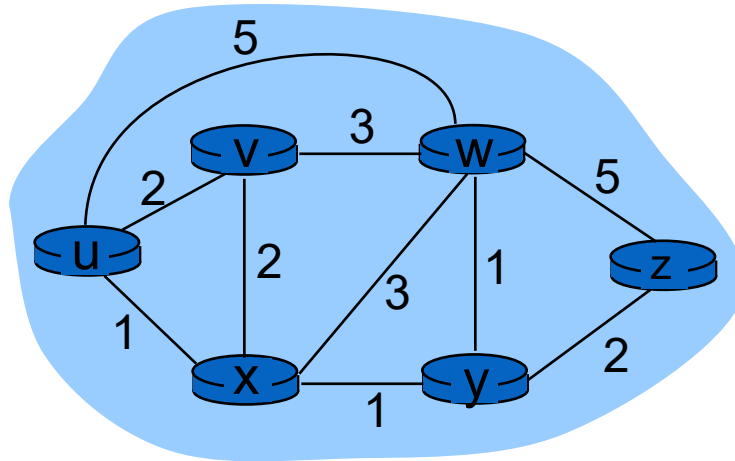


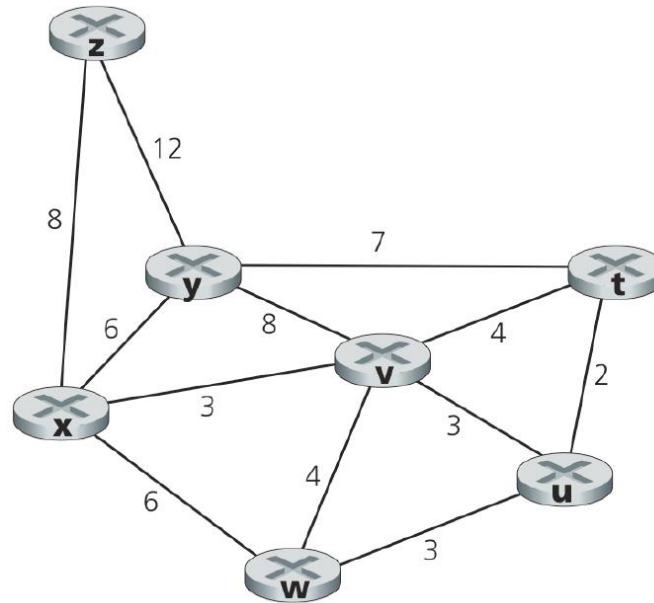
Programming Assignment 4: Dijkstra's Algorithm and Traceroute

- a. Test that you code works correctly by testing it against Figure 4.27.



Step	V=2	V=3	V=4	V=5	V=6	N
0	2,1	1,1	5,1	99,1	99,1	1
1	2,1	----	4,3	2,3	99,1	1,3,
2	----	----	4,3	2,3	99,1	1,3,2,
3	----	----	3,5	----	4,5	1,3,2,5,
4	----	----	----	----	4,5	1,3,2,5,4,
5	----	----	----	----	----	1,3,2,5,4,6,
Shortest path from vertex 1 to 2 is 2						
Shortest path from vertex 1 to 3 is 1						
Shortest path from vertex 1 to 4 is 3						
Shortest path from vertex 1 to 5 is 2						
Shortest path from vertex 1 to 6 is 4						

b. Test your program for the topology given below.



Step	V=2	V=3	V=4	V=5	V=6	V=7	N
0	8,1	6,1	3,1	6,1	99,1	99,1	1
1	8,1	6,1	----	6,1	7,4	6,4	1,4,
2	8,1	----	----	6,1	7,4	6,4	1,4,3,
3	8,1	----	----	----	7,4	6,4	1,4,3,5,
4	8,1	----	----	----	7,4	----	1,4,3,5,7,
5	8,1	----	----	----	----	----	1,4,3,5,7,6,
6	----	----	----	----	----	----	1,4,3,5,7,6,2,
Shortest path from vertex 1 to 2 is 8							
Shortest path from vertex 1 to 3 is 6							
Shortest path from vertex 1 to 4 is 3							
Shortest path from vertex 1 to 5 is 6							
Shortest path from vertex 1 to 6 is 7							
Shortest path from vertex 1 to 7 is 6							

Traceroute (20 points)

Perform a Traceroute between source and destination on the same continent at three different hours of different days. You need to provide screenshots to show that you have done all these experiments. Please do not try websites such as google.com, amazon.com etc as these websites make extensive use of CDNs and you will not get useful results.

Tracert 1 : May 1st 11:30 pm

Microsoft Windows [Version 10.0.17134.706]

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C:\Users\shrey>tracert www.mu.ac.in

Tracing route to www.mu.ac.in [121.241.25.1]
over a maximum of 30 hops:

1	1 ms	<1 ms	<1 ms	RAC2VIS [192.168.1.1]
2	16 ms	13 ms	14 ms	142.254.214.137
3	37 ms	29 ms	26 ms	agg62.bngnyaw02h.northeast.rr.com [24.58.208.109]
4	20 ms	17 ms	16 ms	agg27.ithcnycy02r.northeast.rr.com [24.58.36.152]
5	27 ms	369 ms	25 ms	be1.ithcnycy02r.northeast.rr.com [24.58.32.86]
6	81 ms	36 ms	45 ms	bu-ether15.chcgildt87w-bcr00.tbone.rr.com [66.109.6.72]
7	147 ms	36 ms	124 ms	66.109.5.225
8	37 ms	36 ms	34 ms	ix-ae-27-0.tcore2.ct8-chicago.as6453.net [64.86.79.97]
9	293 ms	201 ms	201 ms	if-ae-22-2.tcore1.ct8-chicago.as6453.net [64.86.79.2]
10	115 ms	217 ms	201 ms	if-ae-26-2.tcore2.nto-new-york.as6453.net [216.6.81.28]
11	252 ms	222 ms	139 ms	if-ae-8-2.tcore1.nto-new-york.as6453.net [63.243.128.69]
12	216 ms	202 ms	116 ms	if-ae-7-2.tcore1.n0v-new-york.as6453.net [63.243.128.26]
13	154 ms	203 ms	203 ms	if-ae-2-2.tcore2.n0v-new-york.as6453.net [216.6.90.22]
14	151 ms	201 ms	201 ms	if-ae-4-2.tcore2.l78-london.as6453.net [80.231.131.157]
15	273 ms	305 ms	305 ms	80.231.131.82
16	*	*	*	Request timed out.
17	*	*	*	Request timed out.
18	287 ms	*	281 ms	115.111.114.58.static-mumbai.vsnl.net.in [115.111.114.58]
19	*	*	*	Request timed out.
20	*	*	*	Request timed out.
21	*	*	*	Request timed out.
22	*	*	*	Request timed out.
23	*	*	*	Request timed out.
24	*	*	*	Request timed out.
25	*	*	*	Request timed out.
26	*	*	*	Request timed out.
27	*	*	*	Request timed out.
28	*	*	*	Request timed out.
29	*	*	*	Request timed out.
30	*	*	*	Request timed out.

Trace complete.

```
C:\Users\shrey>tracert www.stevens.edu
```

Tracing route to www.stevens.edu.cdn.cloudflare.net [104.16.126.51]
over a maximum of 30 hops:

1	1 ms	14 ms	1 ms	RAC2VIS [192.168.1.1]
2	15 ms	14 ms	11 ms	142.254.214.137
3	28 ms	27 ms	30 ms	agg62.bngnyaw02h.northeast.rr.com [24.58.208.109]
4	20 ms	25 ms	18 ms	agg27.ithcnycy02r.northeast.rr.com [24.58.36.152]
5	23 ms	22 ms	20 ms	be1.ithcnycy02r.northeast.rr.com [24.58.32.86]
6	44 ms	48 ms	47 ms	bu-ether15.chcgildt87w-bcr00.tbone.rr.com [66.109.6.72]
7	39 ms	41 ms	32 ms	66.109.5.225
8	56 ms	158 ms	32 ms	ix-ae-27-0.tcore2.ct8-chicago.as6453.net [64.86.79.97]
9	34 ms	32 ms	33 ms	if-ae-22-2.tcore1.ct8-chicago.as6453.net [64.86.79.2]
10	41 ms	35 ms	37 ms	206.82.141.173
11	132 ms	115 ms	54 ms	104.16.126.51

Trace complete.

Tracert 2 : May 2nd 3:00 pm

Microsoft Windows [Version 10.0.17134.706]
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```
C:\Users\shrey>tracert www.mu.ac.in
```

Tracing route to www.mu.ac.in [121.241.25.2]
over a maximum of 30 hops:

1	1 ms	<1 ms	<1 ms	RAC2VIS [192.168.1.1]
2	133 ms	14 ms	15 ms	142.254.214.137
3	335 ms	38 ms	47 ms	agg62.bngnyaw02h.northeast.rr.com [24.58.208.109]
4	27 ms	123 ms	17 ms	agg27.ithcnycy02r.northeast.rr.com [24.58.36.152]
5	29 ms	23 ms	21 ms	be1.ithcnycy02r.northeast.rr.com [24.58.32.86]
6	33 ms	38 ms	38 ms	bu-ether15.chcgildt87w-bcr00.tbone.rr.com [66.109.6.72]
7	145 ms	73 ms	196 ms	66.109.5.225
8	36 ms	30 ms	30 ms	ix-ae-27-0.tcore2.ct8-chicago.as6453.net [64.86.79.97]
9	134 ms	203 ms	203 ms	if-ae-22-2.tcore1.ct8-chicago.as6453.net [64.86.79.2]
10	142 ms	203 ms	203 ms	if-ae-26-2.tcore2.nto-new-york.as6453.net [216.6.81.28]
11	178 ms	110 ms	111 ms	if-ae-32-2.tcore2.ldn-london.as6453.net [63.243.216.23]
12	112 ms	113 ms	115 ms	if-ae-15-2.tcore2.l78-london.as6453.net [80.231.131.117]

```

13 231 ms 227 ms 338 ms 80.231.131.82
14 * * * Request timed out.
15 * * * Request timed out.
16 243 ms 313 ms 304 ms 115.111.114.58.static-mumbai.vsnl.net.in [115.111.114.58]
17 * * * Request timed out.
18 * * * Request timed out.
19 * * * Request timed out.
20 * * * Request timed out.
21 * * * Request timed out.
22 * * * Request timed out.
23 * * * Request timed out.
24 * * * Request timed out.
25 * * * Request timed out.
26 * * * Request timed out.
27 * * * Request timed out.
28 * * * Request timed out.
29 * * * Request timed out.
30 * * * Request timed out.

```

Trace complete.

C:\Users\shrey>tracert www.stevens.edu

Tracing route to www.stevens.edu.cdn.cloudflare.net [104.16.126.51]
over a maximum of 30 hops:

```

 1  9 ms  1 ms  <1 ms  RAC2V1S [192.168.1.1]
 2 102 ms 23 ms 12 ms 142.254.214.137
 3 27 ms 30 ms 26 ms agg62.bngnnyaw02h.northeast.rr.com [24.58.208.109]
 4 19 ms 21 ms 26 ms agg27.ithcnycy02r.northeast.rr.com [24.58.36.152]
 5 79 ms 132 ms 22 ms be1.ithcnycy02r.nyroc.rr.com [24.58.32.86]
 6 38 ms 37 ms 120 ms bu-ether15.chcgildt87w-bcr00.tbone.rr.com [66.109.6.72]
 7 * * 155 ms 66.109.5.225
 8 38 ms 38 ms 34 ms ix-ae-27-0.tcore2.ct8-chicago.as6453.net [64.86.79.97]
 9 36 ms 142 ms 32 ms if-ae-22-2.tcore1.ct8-chicago.as6453.net [64.86.79.2]
10 41 ms 38 ms 38 ms 206.82.141.173
11 31 ms 32 ms 32 ms 104.16.126.51

```

Trace complete.

Tracert 3 : May 3rd 6:00 pm

Microsoft Windows [Version 10.0.17134.706]
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```
C:\Users\shrey>tracert www.mu.ac.in
```

Tracing route to www.mu.ac.in [121.241.25.2]
over a maximum of 30 hops:

```
 1  1 ms  <1 ms  4 ms  RAC2V1S [192.168.1.1]
 2  17 ms  20 ms  14 ms  142.254.214.137
 3  85 ms  37 ms  32 ms  agg62.bngnnyaw02h.northeast.rr.com [24.58.208.109]
 4  174 ms  46 ms  22 ms  agg27.ithcnycy02r.northeast.rr.com [24.58.36.152]
 5  26 ms  22 ms  27 ms  be1.ithcnycy02r.nyroc.rr.com [24.58.32.86]
 6  121 ms  38 ms  43 ms  bu-ether15.chcgildt87w-bcr00.tbone.rr.com [66.109.6.72]
 7  36 ms  29 ms  46 ms  66.109.5.225
 8  37 ms  35 ms  37 ms  ix-ae-27-0.tcore2.ct8-chicago.as6453.net [64.86.79.97]
 9  120 ms  175 ms  202 ms  if-ae-22-2.tcore1.ct8-chicago.as6453.net [64.86.79.2]
10  120 ms  113 ms  161 ms  if-ae-26-2.tcore2.nto-new-york.as6453.net [216.6.81.28]
11  172 ms  112 ms  132 ms  if-ae-32-2.tcore2.ldn-london.as6453.net [63.243.216.23]
12  146 ms  156 ms  111 ms  if-ae-15-2.tcore2.l78-london.as6453.net [80.231.131.117]
13  344 ms  303 ms  303 ms  80.231.131.82
14  *      *      *      Request timed out.
15  *      *      *      Request timed out.
16  *      268 ms  300 ms  115.111.114.58.static-mumbai.vsnl.net.in [115.111.114.58]
17  *      *      *      Request timed out.
18  *      *      *      Request timed out.
19  *      *      *      Request timed out.
20  *      *      *      Request timed out.
21  *      *      *      Request timed out.
22  *      *      *      Request timed out.
23  *      *      *      Request timed out.
24  *      *      *      Request timed out.
25  *      *      *      Request timed out.
26  *      *      *      Request timed out.
27  *      *      *      Request timed out.
28  *      *      *      Request timed out.
29  *      *      *      Request timed out.
30  *      *      *      Request timed out.
```

Trace complete.

```
C:\Users\shrey>tracert www.stevens.edu
```

Tracing route to www.stevens.edu.cdn.cloudflare.net [104.16.126.51]
over a maximum of 30 hops:

```
 1  1 ms  <1 ms  <1 ms  RAC2V1S [192.168.1.1]
```

```

2  26 ms  131 ms  12 ms  142.254.214.137
3  37 ms  480 ms  31 ms  agg62.bngnnyaw02h.northeast.rr.com [24.58.208.109]
4  19 ms  15 ms  21 ms  agg27.ithcnycy02r.northeast.rr.com [24.58.36.152]
5  52 ms  29 ms  24 ms  be1.ithcnycy02r.nyroc.rr.com [24.58.32.86]
6  38 ms  36 ms  123 ms  bu-ether15.chcgildt87w-bcr00.tbone.rr.com [66.109.6.72]
7  148 ms  39 ms  122 ms  66.109.5.225
8  30 ms  35 ms  38 ms  ix-ae-27-0.tcore2.ct8-chicago.as6453.net [64.86.79.97]
9  31 ms  33 ms  32 ms  if-ae-22-2.tcore1.ct8-chicago.as6453.net [64.86.79.2]
10 37 ms  47 ms  36 ms  206.82.141.173
11 34 ms  36 ms  31 ms  104.16.126.51

```

Trace complete.

a. Find the average and standard deviation of the round-trip delays at each of the three hours.

Intra-Continent : USA www.stevens.edu

Days	RTT1	RTT2	RTT3	Average	Std Dev.
Day 1	433	531	315	426.33	88.30
Day 2	420	494	498	470.66	35.86
Day 3	453	882	471	602	198.12

Inter-Continent : India www.mu.ac.in

Days	RTT1	RTT2	RTT3	Average	Std Dev.
Day 1	2107	2088	1932	2042.33	78.40
Day 2	1779	1509	1639	1642.33	110.25
Day 3	1399	1355	1434	1396	32.32

b. Find the number of routers in the path at each of the three hours. Did the paths change during any of the hours?

- The number of routers remains the same i.e. 11 and 16 also it doesn't change the path

c. Try to identify the number of ISP networks that the Traceroute packets pass through from source to destination. Routers with similar names and/or similar IP addresses should be considered as part of the same ISP. In your experiments, do the largest delays occur at the peering interfaces between adjacent ISPs?

- Intra

192, 142, 24, 66, 64, 206, 104

- Inter

142, 24, 66, 64, 216, 63, 80, 115

- Yes, the largest delays occur at peering interfaces between adjacent ISPs

d. Repeat the above for a source and destination on different continents. Compare the intra continent and inter-continent results.

- Differences in their RTTs, Average and Std Dev. Plus the number of Routers.