Part C: RIP-Lite

Distance Vector Routing is implemented using distributed Bellman-Ford algorithm. For periodically exchanging information between neighbors, socket programming is used. Client and Server programs are written. Each node has been assigned a different port number and same IP address. So overall, they will have unique identity. Initially, on all nodes servers are run, then clients are executed. All the initial weights are written in a file which is run for each node and distance vector for each node is initialized using that. After initialization, each client sends its distance vector to all its neighboring nodes. After this information exchange, Bellman Form algorithm is run on each node. If a path through a neighboring node results in a lesser weight, it is updated in its distance vector table. Client checks the modified time of the pickled file dumped after update. If it is modified, then client sends the updated information to all its neighbors.

C.1. a. Routing protocol code is present in the Part C folder.

b. Time taken to find the shortest path between h1 and h2: We started the start_timer after initialization. We started end_timer when the client first sends out its distance vector. On every update sent out by client to the servers, we keep on updating the end_timer. We check if the current and end_time is increasing, which means there is no update sent out, so the distance vector is stabilized. So, we report the time difference of end_timer and start_timer as the time taken to find the shortest route. Check client code for more details.

c. Screenshot of routing table at each node is present below along with time taken by each node for finding the shortest route.

```
/Users/abhinavadarsh/PycharmProjects/pap_analyser/venv/bin/python/Users/abhinavadarsh/Desktop/FCN_HW3/PartC/my_main.py 1 h2
('r4', ('2', 'h2'))
('r1', ('inf', '-'))
('r2', ('inf', '-'))
('r3', ('inf', '-'))
('h2', (0, 'h2'))
('h1', ('inf', '-'))
Server
('Node = ', 'h2')
('Port = ', 51006)
Socket created successfully
('Socket binded to ', 51006)
Socket is listening...
('Got connection from ', 51142)
('Got connection from ', 51148)
('Got connection from ', 51154)
('Got connection from ', 51160)
('Got connection from ', 51166)
('Got connection from ', 51172)
('Got connection from ', 51178)
('Got connection from ', 51184)
('Got connection from ', 51190)
('Got connection from ', 51196)
('Got connection from ', 51202)
('Got connection from ', 51208)
('Got connection from ', 51214)
```

```
/Users/abhinavadarsh/PycharmProjects/pap_analyser/venv/bin/python /Users/abhinavadarsh/Desktop/FCN_HW3/PartC/my_main.py 1 r1 ('r4', ('inf', '-')) ('r1', (0, 'r1')) ('r2', ('10', 'r1')) ('r3', ('6', 'r1')) ('h2', ('inf', '-')) ('h1', ('2', 'r1')) Server ('Node = ', 'r1') ('Port = ', 51002) Socket created successfully ('Socket binded to ', 51002)
```

```
Socket is listening...
('Got connection from ', 51139)
('Got connection from ', 51145)
('Got connection from ', 51151)
('Got connection from ', 51157)
('Got connection from ', 51163)
('Got connection from ', 51169)
('Got connection from ', 51175)
('Got connection from ', 51181)
('Got connection from ', 51187)
('Got connection from ', 51187)
('Got connection from ', 51193)
('Got connection from ', 51199)
('Got connection from ', 51205)
('Got connection from ', 51211)
```

```
('r4', ('4', 'r2'))
('r1', ('10', 'r2'))
('r2', (0, 'r2'))
('r3', ('inf', '-'))
('h2', ('inf', '-'))
('h1', ('inf', '-'))
Server
('Node = ', 'r2')
('Port = ', 51003)
Socket created successfully
('Socket binded to ', 51003)
Socket is listening...
('Got connection from ', 51140)
('Got connection from ', 51146)
('Got connection from ', 51152)
('Got connection from ', 51158)
('Got connection from ', 51164)
('Got connection from ', 51170)
('Got connection from ', 51176)
('Got connection from ', 51182)
('Got connection from ', 51188)
('Got connection from ', 51194)
('Got connection from ', 51200)
('Got connection from ', 51206)
('Got connection from ', 51212)
```

```
('r4', ('5', 'r3'))
('r1', ('6', 'r3'))
('r2', ('inf', '-'))
('r3', (0, 'r3'))
('h2', ('inf', '-'))
('h1', ('inf', '-'))
Server
('Node = ', 'r3')
('Port = ', 51004)
Socket created successfully
('Socket binded to ', 51004)
Socket is listening...
('Got connection from ', 51141)
('Got connection from ', 51147)
('Got connection from ', 51153)
('Got connection from ', 51159)
('Got connection from ', 51165)
('Got connection from ', 51171)
('Got connection from ', 51177)
('Got connection from ', 51183)
('Got connection from ', 51189)
('Got connection from ', 51195)
('Got connection from ', 51201)
```

```
('Got connection from ', 51207)
('Got connection from ', 51213)
```

```
/Users/abhinavadarsh/PycharmProjects/pap_analyser/venv/bin/python/Users/abhinavadarsh/Desktop/FCN_HW3/PartC/my_main.py 1 r4
('r4', (0, 'r4'))
('r1', ('inf', '-'))
('r2', ('4', 'r4'))
('r3', ('5', 'r4'))
('h2', ('2', 'r4'))
('h1', ('inf', '-'))
Server
('Node = ', 'r4')
('Port = ', 51005)
Socket created successfully
('Socket binded to ', 51005)
Socket is listening...
('Got connection from ', 51138)
('Got connection from ', 51144)
('Got connection from ', 51150)
('Got connection from ', 51156)
('Got connection from ', 51162)
('Got connection from ', 51168)
('Got connection from ', 51174)
('Got connection from ', 51180)
('Got connection from ', 51186)
('Got connection from ', 51192)
('Got connection from ', 51198)
('Got connection from ', 51204)
('Got connection from ', 51210)
```

```
/Users/abhinavadarsh/PycharmProjects/pap_analyser/venv/bin/python/Users/abhinavadarsh/Desktop/FCN_HW3/PartC/my_main.py 2 h1
('r4', ('inf', '-'))
('r1', ('2', 'h1'))
('r2', ('inf', '-'))
('r3', ('inf', '-'))
('h2', ('inf', '-'))
('h1', (0, 'h1'))
Client
('Node = ', 'h1')
('Port = ', 51001)
Socket created successfully
Node
           Distance Next Hop
                      inf
r4
r1
                      2
                                             h1
r2
                      inf
r3
                      inf
h2
                      inf
h1
                      0
                                             h1
Socket created successfully
           Distance Next Hop
Node
r4
                      inf
r1
                      2
                                             h1
r2
                      inf
r3
                      inf
h2
                      inf
h1
                      0
                                             h1
Socket created successfully
           Distance Next Hop
Node
r4
                      inf
r1
                      2
                                             h1
r2
                      inf
r3
                      inf
h2
                      inf
h1
                      0
                                             h1
Socket created successfully
           Distance Next Hop
Node
```

		:f	
r4		inf	- h1
r1		2	h1
r2		inf	-
r3		inf	-
h2		inf	
h1		0	h1
	eated succes		
Node	Distance	Next Hop	
r4		inf	-
r1		2	h1
r2		inf	-
r3		inf	-
h2		inf	-
h1		0	h1
	eated succes		
Node	Distance	Next Hop	
r4		inf	-
r1		2	h1
r2		inf	-
r3		inf	-
h2		inf	-
h1		0	h1
Node	Distance	Next Hop	
r4		13	r3
r1		2	h1
r2		12	r1
r3		8	r1
h2		15	r4
h1		0	h1
Node	Distance	Next Hop	-
r4	2.564166	13	r3
r1		2	h1
r2		12	r1
r3		8	r1
h2		15	r4
h1		0	h1
Node	Dictance	Next Hop	HI .
r4	Distalice	13	r3
r1		2	h1
r2		12	r1
r3		8	r1
h2		15	r4
h1	D:-1	O Novet Han	h1
Node	Distance	Next Hop	
r4		13	r3
r1		2	h1
r2		12	r1
r3		8	r1
h2		15	r4
h1		0	h1
Node	Distance	Next Hop	
r4		13	r3
r1		2	h1
r2		12	r1
r3		8	r1
h2		15	r4
h1		0	h1
Node	Distance	Next Hop	
r4		13	r3
r1		2	h1
r2		12	r1
r3		8	r1
h2		15	r4
h1		0	h1
	nce Time fo	r h1 = 217.180967331	

```
/Users/abhinavadarsh/PycharmProjects/pap_analyser/venv/bin/python /Users/abhinavadarsh/Desktop/FCN_HW3/PartC/my_main.py 2 h2
('r4', ('2', 'h2'))
('r1', ('inf', '-'))
('r2', ('inf', '-'))
('r3', ('inf', '-'))
('h2', (0, 'h2'))
('h1', ('inf', '-'))
Client
('Node = ', 'h2')
('Port = ', 51006)
Socket created successfully
Node
           Distance Next Hop
                     2
                                          h2
r4
r1
                     inf
r2
                     inf
r3
                     inf
                     0
h2
                                          h2
h1
                     inf
Socket created successfully
          Distance Next Hop
Node
r4
                     2
                                          h2
                     inf
r2
                     inf
r3
                     inf
                                          h2
h2
                     0
h1
                     inf
Socket created successfully
Node
           Distance Next Hop
                     2
                                          h2
r1
                     inf
r2
                     inf
r3
                     inf
                     0
h2
                                          h2
                     inf
h1
Socket created successfully
Node
           Distance Next Hop
r4
                     2
                                          h2
r1
                     inf
r2
                     inf
r3
                     inf
h2
                     0
                                          h2
h1
                     inf
Socket created successfully
          Distance Next Hop
Node
r4
                     2
                                          h2
r1
                     inf
r2
                     inf
r3
                     inf
h2
                     0
                                          h2
h1
                     inf
Socket created successfully
Node
           Distance Next Hop
                     2
r4
                                          h2
r1
                     inf
r2
                     inf
r3
                     inf
                     0
h2
                                          h2
h1
                     inf
Node
           Distance Next Hop
r4
                                          h2
r1
                     inf
r2
                     6
                                          r4
r3
                     7
                                          r4
                     0
h2
                                          h2
h1
                     inf
Node
           Distance Next Hop
```

r4		2	h2
r1		inf	-
r2		6	r4
r3		7	r4
h2		0	h2
h1		inf	-
Node	Distance	Next Hop	
r4		2	h2
r1		inf	-
r2 r3		6 7	r4 r4
h2		0	h2
h1		inf	-
Node	Distance	Next Hop	
r4		2	h2
r1		inf	-
r2		6	r4
r3		7	r4
h2		0	h2
h1	Dietara	inf	-
Node r4	Distance	Next Hop 2	h2
r4 r1		inf	ΠZ -
r2		6	r4
r3		7	r4
h2		0	h2
h1		inf	
Node	Distance	Next Hop	
r4		2	h2
r1		inf	•
r2		6	r4
r3		7	r4 h2
h2 h1		0 inf	ΠZ -
Node	Distance	Next Hop	
r4	Distance	2	h2
r1		13	r3
r2		6	r4
r3		7	r4
h2		0	h2
h1		15	r3
Node	Distance	Next Hop	L2
r4 r1		2 13	h2 r3
r1 r2		6	r3 r4
r3		7	r4
h2		0	h2
h1		15	r3
Node	Distance	Next Hop	
r4		2	h2
r1		13	r3
r2		6	r4
r3 h2		7 0	r4 h2
h1		15	r3
Node	Distance	Next Hop	
r4	5001100	2	h2
r1		13	r3
r2		6	r4
r3		7	r4
h2		0	h2
h1		15	r3
Node	Distance	Next Hop	L2
r4		2 13	h2 r3
r1 r2		6	r3 r4
14		U	וד

```
r3
                                        r4
h2
                    0
                                        h2
h1
                    15
                                        r3
          Distance Next Hop
Node
r4
                                        h2
                    2
                                        r3
r1
                    13
                                        r4
r2
                    6
r3
                    7
                                        r4
h2
                    0
                                        h2
                    15
h1
                                        r3
Convergence Time for h2 = 416.51391983 milliseconds
```

```
/Users/abhinavadarsh/PycharmProjects/pap_analyser/venv/bin/python/Users/abhinavadarsh/Desktop/FCN_HW3/PartC/my_main.py 2 r1
('r4', ('inf', '-'))
('r1', (0, 'r1'))
('r2', ('10', 'r1'))
('r3', ('6', 'r1'))
('h2', ('inf', '-'))
('h1', ('2', 'r1'))
Client
('Node = ', 'r1')
('Port = ', 51002)
Socket created successfully
           Distance Next Hop
r4
                      inf
r1
                      0
                                             r1
r2
                      10
                                             r1
r3
                      6
                                             r1
h2
                      inf
                                             r1
Socket created successfully
           Distance Next Hop
Node
r4
                      inf
r1
                      0
                                             r1
r2
                      10
                                             r1
r3
                      6
                                             r1
h2
                      inf
h1
                      2
                                             r1
Socket created successfully
Node
           Distance Next Hop
r4
                      inf
r1
                      0
                                             r1
r2
                      10
                                             r1
r3
                      6
                                             r1
                      inf
h2
h1
                      2
                                             r1
Socket created successfully
Node
           Distance Next Hop
r4
                      inf
                      0
                                             r1
                      10
r2
                                             r1
r3
                      6
                                             r1
h2
                      inf
h1
                                             r1
Socket created successfully
           Distance Next Hop
Node
                      inf
r1
                      0
                                             r1
r2
                      10
                                             r1
r3
                      6
                                             r1
                      \quad \text{inf} \quad
h2
h1
                                             r1
Socket created successfully
           Distance Next Hop
Node
r4
                      \quad \text{inf} \quad
r1
                      0
                                             r1
```

```
r2
                   10
                                        r1
r3
                   6
                                        r1
h2
                   inf
h1
                                        r1
Node
          Distance Next Hop
                                        r3
r4
                   11
r1
                   0
                                        r1
r2
                   10
                                        r1
r3
                   6
                                        r1
h2
                   13
                                        r4
h1
                   2
                                        r1
Node
          Distance Next Hop
                                        r3
r4
                   11
                   0
r1
                                       r1
r2
                   10
                                       r1
r3
                   6
                                        r1
h2
                   13
                                        r4
h1
                   2
                                        r1
Node
          Distance Next Hop
                                        r3
r4
                   11
r1
                   0
                                       r1
r2
                   10
                                        r1
r3
                   6
                                        r1
h2
                   13
                                        r4
h1
                   2
                                        r1
Node
          Distance Next Hop
                                        r3
r4
                   11
r1
                   0
                                        r1
r2
                   10
                                        r1
r3
                   6
                                        r1
h2
                   13
                                        r4
h1
                   2
                                        r1
          Distance Next Hop
Node
                                        r3
r4
                   11
r1
                   0
                                        r1
r2
                   10
                                        r1
r3
                   6
                                        r1
h2
                   13
                                        r4
h1
                   2
                                        r1
          Distance Next Hop
Node
r4
                   11
                                        r3
r1
                   0
                                       r1
r2
                   10
                                        r1
r3
                   6
                                        r1
h2
                   13
                                       r4
h1
                   2
                                        r1
Convergence Time for r1 = 232.665061951 milliseconds
```

```
/Users/abhinavadarsh/PycharmProjects/pap\_analyser/venv/bin/python /Users/abhinavadarsh/Desktop/FCN\_HW3/PartC/my\_main.py\ 2\ r2
('r4', ('4', 'r2'))
('r1', ('10', 'r2'))
('r2', (0, 'r2'))
('r3', ('inf', '-'))
('h2', ('inf', '-'))
('h1', ('inf', '-'))
Client
('Node = ', 'r2')
('Port = ', 51003)
Socket created successfully
Node
            Distance Next Hop
                                                r2
r4
                        10
r1
                                                r2
r2
                        0
                                                r2
                        \quad \text{inf} \quad
r3
h2
                        inf
h1
                        inf
```

Socket cr	eated succe	ccfully	
Node		Next Hop	
r4	Distalle	4	r2
r1		10	r2
r2		0	r2
r3		inf	-
			•
h2		inf inf	-
h1			-
	eated succe		
Node	Distance	Next Hop	
r4		4	r2
r1		10	r2
r2		0	r2
r3		inf	-
h2		inf	•
h1		inf	-
Socket cr	eated succe	ssfully	
Node	Distance	Next Hop	
r4		4	r2
r1		10	r2
r2		0	r2
r3		inf	-
h2		inf	-
h1		inf	-
	eated succes		
Node		Next Hop	
r4	Distance	4	r2
		10	r2
r1			
r2		0	r2
r3		inf	•
h2		inf	•
h1		inf	-
	eated succe		
Node	Distance	Next Hop	
r4		4	r2
r1		10	r2
r2		0	r2
r3		inf	-
h2		inf	-
h1		inf	-
Node	Distance	Next Hop	
r4		4	r2
r1		10	r2
r2		0	r2
r3		9	r4
h2		6	r4
h1		12	r1
Node	Distance	Next Hop	
r4	2.5341166	4	r2
r1		10	r2
r2		0	r2
r3		9	r4
h2		6	r4 r4
h1		12	
	Diet		r1
Node	Distance	Next Hop	
r4		4	r2
r1		10	r2
r2		0	r2
r3		9	r4
h2		6	r4
h1		12	r1
Node	Distance	Next Hop	
r4		4	r2
r1		10	r2
r2		0	r2
r3		9	r4

```
h2
                                        r4
                   6
h1
                   12
                                        r1
Node
          Distance Next Hop
r4
                                        r2
                   4
r1
                   10
                                        r2
                   0
                                        r2
r2
                   9
                                        r4
r3
h2
                   6
                                        r4
h1
                   12
                                        r1
Node
          Distance Next Hop
r4
                   4
                                        r2
r1
                   10
                                        r2
                   0
                                        r2
r2
r3
                   9
                                        r4
h2
                   6
                                        r4
h1
                   12
                                        r1
Convergence Time for r2 = 210.383892059 milliseconds
```

```
Users/abhinavadarsh/PycharmProjects/pap\_analyser/venv/bin/python/Users/abhinavadarsh/Desktop/FCN\_HW3/PartC/my\_main.py\ 2\ r3
('r4', ('5', 'r3'))
('r1', ('6', 'r3'))
('r2', ('inf', '-'))
('r3', (0, 'r3'))
('h2', ('inf', '-'))
('h1', ('inf', '-'))
Client
('Node = ', 'r3')
('Port = ', 51004)
Socket created successfully
Node
           Distance Next Hop
                     5
r4
                                           r3
                                           r3
r1
                     6
r2
                     inf
r3
                     0
                                           r3
h2
                     inf
                     inf
h1
Socket created successfully
           Distance Next Hop
Node
r4
                     5
                                           r3
r1
                     6
                                           r3
r2
                     inf
r3
                     0
                                           r3
h2
                     inf
h1
                     inf
Socket created successfully
           Distance Next Hop
Node
r4
                     5
                                           r3
r1
                     6
                                           r3
r2
                     inf
r3
                     0
                                           r3
                     inf
h2
h1
                     inf
Socket created successfully
           Distance Next Hop
Node
                                           r3
r4
                     5
                     6
r1
                                           r3
r2
                     inf
r3
                     0
                                           r3
h2
                     inf
Socket created successfully
Node
           Distance Next Hop
r4
                     5
                                           r3
                     6
r1
                                           r3
                     inf
r2
r3
                     0
                                           r3
```

```
h2
                   inf
Socket created successfully
          Distance Next Hop
Node
r4
                                       r3
                   5
r1
                   6
                                       r3
r2
                   inf
r3
                   0
                                       r3
h2
                   inf
h1
                   inf
          Distance Next Hop
Node
r4
                   5
                                       r3
r1
                   6
                                       r3
                   9
r2
                                       r4
r3
                   0
                                       r3
h2
                   7
                                       r4
                   8
h1
                                       r1
Node
          Distance Next Hop
r4
                   5
                                       r3
r1
                   6
                                       r3
                   9
r2
                                       r4
r3
                   0
                                       r3
h2
                   7
                                       r4
h1
                   8
                                       r1
Node
          Distance Next Hop
r4
                                       r3
r1
                   6
                                       r3
r2
                   9
                                       r4
r3
                   0
                                       r3
h2
                   7
                                       r4
h1
                   8
                                       r1
Node
          Distance Next Hop
                                       r3
r4
                   5
r1
                   6
                                       r3
r2
                   9
                                       r4
r3
                   0
                                       r3
                   7
h2
                                       r4
h1
                   8
                                       r1
Node
          Distance Next Hop
r4
                   5
                                       r3
r1
                   6
                                       r3
r2
                   9
                                       r4
r3
                   0
                                       r3
                   7
h2
                                       r4
h1
                   8
                                       r1
Node
          Distance Next Hop
                                       r3
r4
                   5
r1
                   6
                                       r3
r2
                   9
                                       r4
                   0
r3
                                       r3
h2
                   7
                                       r4
                   8
                                       r1
Convergence Time for r3 = 209.877967834 milliseconds
```

```
/Users/abhinavadarsh/PycharmProjects/pap_analyser/venv/bin/python /Users/abhinavadarsh/Desktop/FCN_HW3/PartC/my_main.py 2 r4
('r4', (0, 'r4'))
('r1', ('inf', '-'))
('r2', ('4', 'r4'))
('r3', ('5', 'r4'))
('h2', ('2', 'r4'))
('h1', ('inf', '-'))
Client
('Node = ', 'r4')
('Port = ', 51005)
Socket created successfully
Node Distance Next Hop
```

r4	0	r4	
r1	inf	-	
r2	4	r4	
r3	5	r4	
h2	2	r4	
h1	inf	_	
	ed successfully		
Node D	istance Next Hop		
r4	0	r4	
r1	inf	-	
r2	4	r4	
r3	5	r4	
h2	2	r4	
		14	
h1	inf	-	
Socket create	ed successfully		
	istance Next Hop		
		.4	
r4	0	r4	
r1	inf	-	
r2	4	r4	
r3	5	r4	
h2	2	r4	
h1	inf	-	
	ed successfully		
	istance Next Hop		
r4	0	r4	
r1	inf	-	
r2	4	r4	
r3	5	r4	
h2	2	r4	
h1	inf		
		-	
	ed successfully		
Node D	istance Next Hop		
r4	0	r4	
r1	inf	-	
r2	4	r4	
r3	5	r4	
h2	2	r4	
		14	
h1	inf	-	
Socket create	ed successfully		
Node D	istance Next Hop		
		.4	
r4	0	r4	
r1	inf	-	
r2	4	r4	
r3	5	r4	
h2	2	r4	
h1	inf	-	
	istance Next Hop		
r4	0	r4	
r1	11	r3	
r2	4	r4	
r3	5	r4	
h2	2	r4	
h1	13	r3	
Node D	istance Next Hop		
r4	0	r4	
	11		
r1		r3	
r2	4	r4	
r3	5	r4	
h2	2	r4	
h1	13	r3	
Node D	istance Next Hop		
r4	0	r4	
	11	r3	
r1			
r2	4	r4	
r3	5	r4	
h2	2	r4	

h1		13	r3
Node	Distance	Next Hop	
r4		0	r4
r1		11	r3
r2		4	r4
r3		5	r4
h2		2	r4
h1		13	r3
Node	Distance	Next Hop	
r4		0	r4
r1		11	r3
r2		4	r4
r3		5	r4
h2		2	r4
h1		13	r3
Node	Distance	Next Hop	
r4		0	r4
r1		11	r3
r2		4	r4
r3		5	r4
h2		2	r4
h1		13	r3
Converge	nce Time fo	r r4 = 217.29803085	3 milliseconds

C2. A. If any weight is changed in the weights file, we keep on checking it periodically every 15 seconds. If there is any change in the weight, we update the distance vector of the connecting nodes of the link updated. Time taken for convergence is measured in similar way as for part C1.b.

The distance vector, for this example r1 and r3 are initialized again from the weights file and algorithm is run again for convergence.

C3. If one of the links has a negative weight, explain how you handle this situation.

If a network topology contains a negative weight, then on each comparison the weight lowers and it can keep on running forever. But, Bellman ford algorithm can detect the negative weights in a graph and can signal that. It adds a check after the relax function to see if there is a negative cycle. If there are no negative cycles, then after relaxation function, all weights should be at their lowest value. But, if the below check is true for any edge, then that edge is negative.

```
// Step 3: check for negative-weight cycles
for each edge (u, v) with weight w in edges:
   if distance[u] + w < distance[v]:
        error "Graph contains a negative-weight cycle"</pre>
```

Reference: https://en.wikipedia.org/wiki/Bellman%E2%80%93Ford_algorithm

One way to handle the negative weights would be to limit the number of times the algorithm runs (similar to number of hops limited to 16).