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TELCOMMUNICATION SOFTWARE

Practical Work N°3

Task n°1 - Dijkstra Algorithm

I couldn't import your biblio so I did the function myself.

```
File "C:\Users\Lucie\Desktop\COURS\AERO4\S1\TELECOM\profpw3.py", line 26, in
<module>
    from pq import PriorityQueue, Graph, Vertex
ImportError: cannot import name 'PriorityQueue' from 'pq' (C:\Users\Lucie\
\anaconda3\lib\site-packages\pq\__init__.py)
```

Here is the main code, with the Graph class and the Dijkstra function. You will find the full code in the python file PW3.py in Ortus.

```
11 from queue import PriorityQueue
12
13 #%%-----Dijkstra Algorithm-----
14
15 class Graph:
16     def __init__(self, num_of_vertices):
17         self.v = num_of_vertices
18         self.edges = [[-1 for i in range(num_of_vertices)] for j in range(num_of_vertices)]
19         self.visited = []
20
21     def add_edge(self, u, v, weight):
22         self.edges[u][v] = weight
23         self.edges[v][u] = weight
24
25
26
27 def dijkstra(graph, start_vertex):
28     D = {v:float('inf') for v in range(graph.v)}
29     D[start_vertex] = 0
30
31     pq = PriorityQueue()
32     pq.put((0, start_vertex))
33
34     while not pq.empty():
35         (dist, current_vertex) = pq.get()
36         graph.visited.append(current_vertex)
37
38         for neighbor in range(graph.v):
39             if graph.edges[current_vertex][neighbor] != -1:
40                 distance = graph.edges[current_vertex][neighbor]
41                 if neighbor not in graph.visited:
42                     old_cost = D[neighbor]
43                     new_cost = D[current_vertex] + distance
44                     if new_cost < old_cost:
45                         pq.put((new_cost, neighbor))
46                         D[neighbor] = new_cost
47
48     return D
```

For each figure I had to enter the coordinates in a list

```
###Figure 1

Fig1 = [(('u', 'v', 2), ('u', 'w', 5), ('u', 'x', 1), ('v', 'w', 3), ('v', 'x', 2),
        ('w', 'z', 5), ('w', 'y', 1), ('w', 'x', 3), ('x', 'y', 1), ('z', 'y', 1))]

l = ['u', 'v', 'w', 'x', 'y', 'z']

g = Graph(len(l))
g.add_edge(0, 1, 2)
g.add_edge(0, 2, 5)
g.add_edge(0, 3, 1)
g.add_edge(1, 2, 3)
g.add_edge(1, 3, 2)
g.add_edge(2, 5, 5)
g.add_edge(2, 3, 3)
g.add_edge(3, 4, 1)
g.add_edge(4, 5, 1)
```

Fig1 is unused, it was to for me to have a better view of the figure and to complete the graph manually. You can see that 0 = u; 1 = v; 2 = w; ... I think I can still optimize the code but for now it was easier to work with only numbers on the Dijkstra algorithm.

```
### Figure 2

Fig2 = [(('A', 'B', 3), ('A', 'F', 6), ('A', 'E', 1), ('B', 'E', 1),
        ('B', 'C', 4), ('C', 'D', 9), ('D', 'E', 1), ('E', 'F', 2))]

l = ['A', 'B', 'C', 'D', 'E', 'F']

g = Graph(len(l))
g.add_edge(0, 1, 3)
g.add_edge(0, 4, 1)
g.add_edge(0, 5, 6)
g.add_edge(1, 2, 4)
g.add_edge(2, 3, 9)
g.add_edge(3, 4, 1)
g.add_edge(4, 5, 2)
```

```
###Figure 3

Fig3 = [(('u', 'v', 3), ('u', 'w', 2), ('v', 'y', 2), ('v', 'x', 1),
        ('w', 's', 4), ('t', 's', 3), ('x', 'z', 3), ('x', 't', 5), ('y', 'z', 1))]

l = ['u', 'v', 'w', 'x', 'y', 'z', 't', 's']

g = Graph(len(l))
g.add_edge(0, 1, 3)
g.add_edge(0, 2, 2)
g.add_edge(1, 3, 1)
g.add_edge(1, 4, 2)
g.add_edge(1, 5, 1)
g.add_edge(2, 7, 4)
g.add_edge(3, 5, 4)
g.add_edge(3, 6, 3)
g.add_edge(6, 7, 3)
```

```

#%%Figure 4

Fig4 = [( 'A', 'B', 2), ('A', 'C', 3), ('B', 'C', 1), ('B', 'D', 1),
        ('B', 'E', 4), ('C', 'F', 5), ('F', 'E', 1), ('F', 'G', 1)]

l = ['A', 'B', 'C', 'D', 'E', 'F', 'G']

g = Graph(len(l))
g.add_edge(0, 1, 2)
g.add_edge(0, 2, 3)
g.add_edge(1, 2, 1)
g.add_edge(1, 3, 1)
g.add_edge(1, 4, 4)
g.add_edge(2, 5, 5)
g.add_edge(4, 5, 1)
g.add_edge(5, 6, 1)

```

```

#%%Figure 5

Fig5 = [( 'A', 'B', 5), ('A', 'C', 10), ('B', 'C', 3), ('B', 'D', 11), ('C', 'D', 2)]

l = ['A', 'B', 'C', 'D']

g = Graph(len(l))
g.add_edge(0, 1, 5)
g.add_edge(0, 2, 10)
g.add_edge(1, 2, 3)
g.add_edge(1, 3, 11)
g.add_edge(2, 3, 2)

```

Each figure is on a different cell so you have to first run the two first cells that are the PriorityQueue importation and the main code of Graph and Dijkstra. Then you have to run the cell of the chosen figure. I plan on optimizing this code by adding a function that allow you to chose which figure you want and upload it directly without you having to run the appropriate cell.

Then, the last step is to run the last cell. You can chose the starting point in the figure by changing the number start. One again here 0 = 'u'.

```

start = 0
D = dijkstra(g, start)

print(D)

for vertex in range(len(D)):
    print("Distance from ", l[start], " to ", l[vertex], "is", D[vertex])

```

I also plan to optimize that part. If I do the function where you only chose the figure, I can add an argument to it where you also chose the beginning.

The results are :

Figure 1

```
Distance from u to u is 0
Distance from u to v is 2
Distance from u to w is 4
Distance from u to x is 1
Distance from u to y is 2
Distance from u to z is 3
```

Figure 2

```
Distance from A to A is 0
Distance from A to B is 3
Distance from A to C is 7
Distance from A to D is 2
Distance from A to E is 1
Distance from A to F is 3
```

Figure 3

```
Distance from u to u is 0
Distance from u to v is 3
Distance from u to w is 2
Distance from u to x is 4
Distance from u to y is 5
Distance from u to z is 4
Distance from u to t is 7
Distance from u to s is 6
```

Figure 4

```
Distance from A to A is 0
Distance from A to B is 2
Distance from A to C is 3
Distance from A to D is 3
Distance from A to E is 6
Distance from A to F is 7
Distance from A to G is 8
```

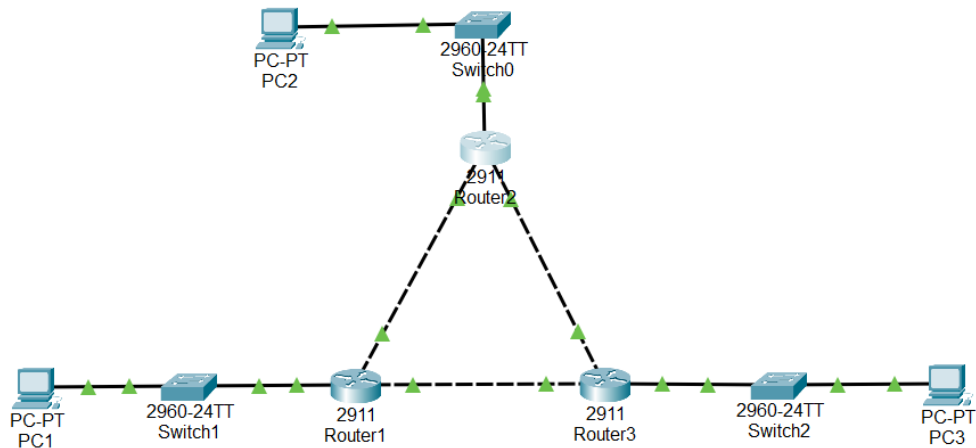
Figure 5

```
Distance from A to A is 0
Distance from A to B is 5
Distance from A to C is 8
Distance from A to D is 10
```

I verified all the results manually and they are all good.

Task n°2 - OSPF experiment

I recreated the network topology and I addressed as in the table below :



Addressing Table

Device	Interface	IP Address	Subnet Mask	Default Gateway
R1	Fa0/0	172.16.1.17	255.255.255.240	N/A
	S0/0/0	192.168.10.1	255.255.255.252	N/A
	S0/0/1	192.168.10.5	255.255.255.252	N/A
R2	Fa0/0	10.10.10.1	255.255.255.0	N/A
	S0/0/0	192.168.10.2	255.255.255.252	N/A
	S0/0/1	192.168.10.9	255.255.255.252	N/A
R3	Fa0/0	172.16.1.33	255.255.255.248	N/A
	S0/0/0	192.168.10.6	255.255.255.252	N/A
	S0/0/1	192.168.10.10	255.255.255.252	N/A
PC1	NIC	172.16.1.20	255.255.255.240	172.16.1.17
PC2	NIC	10.10.10.10	255.255.255.0	10.10.10.1
PC3	NIC	172.16.1.35	255.255.255.248	172.16.1.33

```
Router#sh ip int brief
Interface      IP-Address      OK? Method Status      Protocol
GigabitEthernet0/0  10.10.10.1      YES manual up          up
GigabitEthernet0/1  192.168.10.2    YES manual up          up
GigabitEthernet0/2  192.168.10.9    YES manual up          up
Vlan1          unassigned      YES unset  administratively down down
```

Configure OSPF on the R1 Router :

```
R1#sh ip int brief
Interface                IP-Address      OK? Method Status      Protocol
GigabitEthernet0/0       192.168.10.1    YES manual up          up
GigabitEthernet0/1       192.168.10.5    YES manual up          up
GigabitEthernet0/2       172.16.1.17     YES manual up          up
Vlan1                    unassigned      YES unset  administratively down down
R1#

R1#config t
Enter configuration commands, one per line. End with CNTL/Z.
R1(config)#router ospf 1
R1(config-router)#network 172.16.1.16 0.0.0.15 area 0
R1(config-router)#network 192.168.10.0 0.0.0.3 area 0
R1(config-router)#network 192.168.10.4 0.0.0.3 area 0
R1(config-router)#
02:27:29: %OSPF-6-AREACHG: 192.168.10.4/0 changed from area 3 to area 0

R1(config-router)#end
R1#
%SYS-5-CONFIG_I: Configured from console by console
```

Configure OSPF on the R2 Router :

```
R2#sh ip int brief
Interface                IP-Address      OK? Method Status      Protocol
GigabitEthernet0/0       10.10.10.1      YES manual up          up
GigabitEthernet0/1       192.168.10.2    YES manual up          up
GigabitEthernet0/2       192.168.10.9    YES manual up          up
Vlan1                    unassigned      YES unset  administratively down down
R2#config t
Enter configuration commands, one per line. End with CNTL/Z.
R2(config)#router ospf 1
R2(config-router)#network 10.10.10.0 0.0.0.255 area 0
R2(config-router)#network 192.168.10.0 0.0.0.3 area 0
R2(config-router)#
00:13:47: %OSPF-5-ADJCHG: Process 1, Nbr 192.168.10.5 on GigabitEthernet0/1 from LOADING to FULL, Loading Done

R2(config-router)#network 192.168.10.8 0.0.0.3 area 0
R2(config-router)#end
R2#
%SYS-5-CONFIG_I: Configured from console by console
```

Configure OSPF on the R3 Router :

I forgot to rename the Router R3 so I did it just after

```
Router(config)#router ospf 1
Router(config-router)#network 172.16.1.32 0.0.0.7 area 0
Router(config-router)#network 192.168.10.4 0.0.0.3 area 0
Router(config-router)#
00:02:58: %OSPF-5-ADJCHG: Process 1, Nbr 192.168.10.5 on GigabitEthernet0/0 from LOADING to FULL, Loading Done

Router(config-router)#network 192.168.10.8 0.0.0.3 area 0
Router(config-router)#e
00:03:36: %OSPF-5-ADJCHG: Process 1, Nbr 192.168.10.9 on GigabitEthernet0/2 from LOADING to FULL, Loading Done

Router(config)#end
Router#
%SYS-5-CONFIG_I: Configured from console by console

Router#configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
Router(config)#hostname R3
R3(config)#
```

IDs :

```
R1#show ip protocols
Routing Protocol is "ospf 1"
  Outgoing update filter list for all interfaces is not set
  Incoming update filter list for all interfaces is not set
  Router ID 192.168.10.5
  Number of areas in this router is 2. 2 normal 0 stub 0 nssa
  Maximum path: 4
```

R1 ID : 192.168.10.5

```
R2>en
R2#show ip ospf
Routing Process "ospf 1" with ID 192.168.10.9
  Supports only single TOS(TOS0) routes
  Supports opaque LSA
  SPF schedule delay 5 secs, Hold time between two SPFs 10
secs
```

R2 ID : 192.168.10.9

```
R3#show ip ospf int
GigabitEthernet0/1 is up, line protocol is up
  Internet address is 172.16.1.33/29, Area 0
  Process ID 1, Router ID 192.168.10.10, Network Type BROADCAST, Cost: 1
  Transmit Delay is 1 sec, State DR, Priority 1
  Designated Router (ID) 192.168.10.10, Interface address 172.16.1.33
  No backup designated router on this network
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    Hello due in 00:00:03
```

R3 ID : 192.168.10.10

Use loopback addresses to change the router IDs of the routers in the topology

```
R1>en
R1#config t
Enter configuration commands, one per line.  End with CNTL/Z.
R1(config)#int loopback 0

R1(config-if)#
%LINK-5-CHANGED: Interface Loopback0, changed state to up

%LINEPROTO-5-UPDOWN: Line protocol on Interface Loopback0,
changed state to up

R1(config-if)#ip address 10.1.1.1 255.255.255.255
R1(config-if)#end
R1#
%SYS-5-CONFIG_I: Configured from console by console
```

```
R2>en
R2#config t
Enter configuration commands, one per line.  End with CNTL/Z.
R2(config)#int loopback 0

R2(config-if)#
%LINK-5-CHANGED: Interface Loopback0, changed state to up

%LINEPROTO-5-UPDOWN: Line protocol on Interface Loopback0,
changed state to up

R2(config-if)#ip address 10.2.2.2 255.255.255.255
R2(config-if)#end
R2#
%SYS-5-CONFIG_I: Configured from console by console
```



```

R3(config)#interface loopback 0
R3(config-if)#
%LINK-5-CHANGED: Interface Loopback0, changed state to up
%LINEPROTO-5-UPDOWN: Line protocol on Interface Loopback0, changed state to up
R3(config-if)#ip address 10.3.3.3 255.255.255.255
R3(config-if)#end
R3#
%SYS-5-CONFIG_I: Configured from console by console

```

Reload the routers :

```

R1#reload
System configuration has been modified. Save? [yes/no]:yes
Building configuration...
[OK]
Proceed with reload? [confirm]

```

```

R1>show ip ospf
Routing Process "ospf 1" with ID 10.1.1.1

```

```

R2>en
R2#show ip ospf int
GigabitEthernet0/0 is up, line protocol is up
Internet address is 10.10.10.1/24, Area 0
Process ID 1, Router ID 10.2.2.2, Network Type BROADCAST,

```

```

R3>en
R3#show ip ospf
Routing Process "ospf 1" with ID 10.3.3.3

```

R1 neighbor ID :

Neighbor ID	Pri	State	Dead Time	Address	Interface
10.2.2.2	1	FULL/DR	00:00:36	192.168.10.2	GigabitEthernet0/0
10.3.3.3	1	FULL/DR	00:00:35	192.168.10.6	GigabitEthernet0/1

R2 neighbor ID :

Neighbor ID	Pri	State	Dead Time	Address	Interface
10.3.3.3	1	FULL/DR	00:00:31	192.168.10.10	GigabitEthernet0/2
10.1.1.1	1	FULL/BDR	00:00:32	192.168.10.1	GigabitEthernet0/1

R3 neighbor ID :

Neighbor ID	Pri	State	Dead Time	Address	Interface
10.2.2.2	1	FULL/BDR	00:00:37	192.168.10.9	GigabitEthernet0/2
10.1.1.1	1	FULL/BDR	00:00:37	192.168.10.5	GigabitEthernet0/0

```
R1#show ip protocols
```

```
Routing Protocol is "ospf 1"
  Outgoing update filter list for all interfaces is not set
  Incoming update filter list for all interfaces is not set
  Router ID 10.1.1.1
  Number of areas in this router is 1. 1 normal 0 stub 0 nssa
  Maximum path: 4
  Routing for Networks:
    172.16.1.16 0.0.0.15 area 0
    192.168.10.0 0.0.0.3 area 0
    192.168.10.4 0.0.0.3 area 0
  Routing Information Sources:
    Gateway         Distance      Last Update
    10.1.1.1         110          00:27:05
    10.2.2.2         110          00:27:05
    10.3.3.3         110          00:27:05
    192.168.10.5     110          00:53:02
    192.168.10.9     110          00:39:26
    192.168.10.10    110          00:37:26
  Distance: (default is 110)
```

Examine OSPF Routes in the Routing Tables

```
R1#show ip route
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2, E - EGP
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area
       * - candidate default, U - per-user static route, o - ODR
       P - periodic downloaded static route
```

```
Gateway of last resort is not set
```

```
    10.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
C       10.1.1.1/32 is directly connected, Loopback0
O       10.10.10.0/24 [110/2] via 192.168.10.2, 00:01:22, GigabitEthernet0/0
    172.16.0.0/16 is variably subnetted, 3 subnets, 3 masks
C       172.16.1.16/28 is directly connected, GigabitEthernet0/2
L       172.16.1.17/32 is directly connected, GigabitEthernet0/2
O       172.16.1.32/29 [110/2] via 192.168.10.6, 00:04:03, GigabitEthernet0/1
    192.168.10.0/24 is variably subnetted, 5 subnets, 2 masks
C       192.168.10.0/30 is directly connected, GigabitEthernet0/0
L       192.168.10.1/32 is directly connected, GigabitEthernet0/0
C       192.168.10.4/30 is directly connected, GigabitEthernet0/1
L       192.168.10.5/32 is directly connected, GigabitEthernet0/1
O       192.168.10.8/30 [110/2] via 192.168.10.2, 00:01:22, GigabitEthernet0/0
        [110/2] via 192.168.10.6, 00:01:22, GigabitEthernet0/1
```

```
R1#
```

Ping from PC1 :

```
Ping statistics for 10.10.10.1:
  Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
  Minimum = 0ms, Maximum = 0ms, Average = 0ms

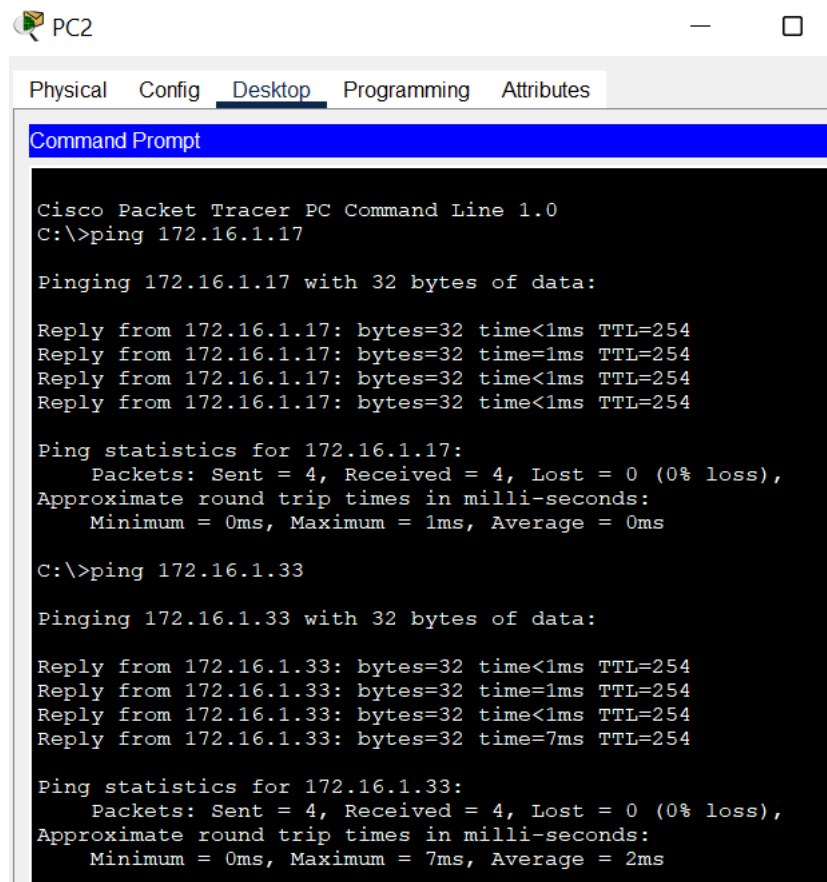
C:\>ping 172.16.1.33

Pinging 172.16.1.33 with 32 bytes of data:

Reply from 172.16.1.33: bytes=32 time<1ms TTL=254
Reply from 172.16.1.33: bytes=32 time<1ms TTL=254
Reply from 172.16.1.33: bytes=32 time<1ms TTL=254
Reply from 172.16.1.33: bytes=32 time<1ms TTL=254

Ping statistics for 172.16.1.33:
  Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
  Minimum = 0ms, Maximum = 0ms, Average = 0ms
```

Ping from PC2 :



The screenshot shows the PC2 configuration window in Cisco Packet Tracer. The 'Desktop' tab is selected, displaying a 'Command Prompt' window. The command prompt shows the execution of two ping commands from the PC's perspective. The first command is 'ping 172.16.1.17', which successfully receives four replies with 0% loss and an average round trip time of 0ms. The second command is 'ping 172.16.1.33', which also successfully receives four replies with 0% loss and an average round trip time of 2ms.

```
Cisco Packet Tracer PC Command Line 1.0
C:\>ping 172.16.1.17

Pinging 172.16.1.17 with 32 bytes of data:

Reply from 172.16.1.17: bytes=32 time<1ms TTL=254
Reply from 172.16.1.17: bytes=32 time=1ms TTL=254
Reply from 172.16.1.17: bytes=32 time<1ms TTL=254
Reply from 172.16.1.17: bytes=32 time<1ms TTL=254

Ping statistics for 172.16.1.17:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
    Approximate round trip times in milli-seconds:
        Minimum = 0ms, Maximum = 1ms, Average = 0ms

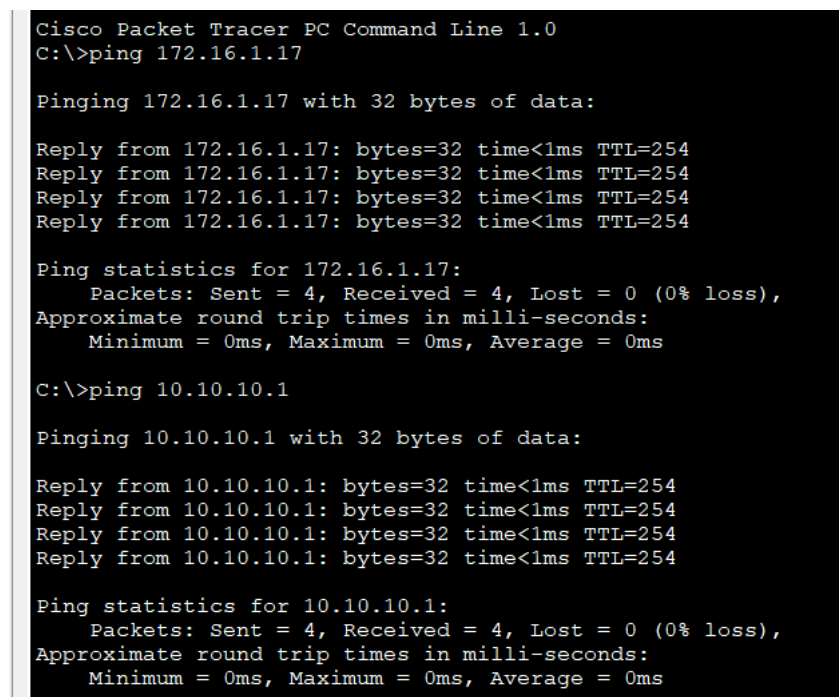
C:\>ping 172.16.1.33

Pinging 172.16.1.33 with 32 bytes of data:

Reply from 172.16.1.33: bytes=32 time<1ms TTL=254
Reply from 172.16.1.33: bytes=32 time=1ms TTL=254
Reply from 172.16.1.33: bytes=32 time<1ms TTL=254
Reply from 172.16.1.33: bytes=32 time=7ms TTL=254

Ping statistics for 172.16.1.33:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
    Approximate round trip times in milli-seconds:
        Minimum = 0ms, Maximum = 7ms, Average = 2ms
```

Ping from PC3 :



The screenshot shows the PC3 configuration window in Cisco Packet Tracer. The 'Desktop' tab is selected, displaying a 'Command Prompt' window. The command prompt shows the execution of two ping commands from the PC's perspective. The first command is 'ping 172.16.1.17', which successfully receives four replies with 0% loss and an average round trip time of 0ms. The second command is 'ping 10.10.10.1', which also successfully receives four replies with 0% loss and an average round trip time of 0ms.

```
Cisco Packet Tracer PC Command Line 1.0
C:\>ping 172.16.1.17

Pinging 172.16.1.17 with 32 bytes of data:

Reply from 172.16.1.17: bytes=32 time<1ms TTL=254
Reply from 172.16.1.17: bytes=32 time<1ms TTL=254
Reply from 172.16.1.17: bytes=32 time<1ms TTL=254
Reply from 172.16.1.17: bytes=32 time<1ms TTL=254

Ping statistics for 172.16.1.17:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
    Approximate round trip times in milli-seconds:
        Minimum = 0ms, Maximum = 0ms, Average = 0ms

C:\>ping 10.10.10.1

Pinging 10.10.10.1 with 32 bytes of data:

Reply from 10.10.10.1: bytes=32 time<1ms TTL=254
Reply from 10.10.10.1: bytes=32 time<1ms TTL=254
Reply from 10.10.10.1: bytes=32 time<1ms TTL=254
Reply from 10.10.10.1: bytes=32 time<1ms TTL=254

Ping statistics for 10.10.10.1:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
    Approximate round trip times in milli-seconds:
        Minimum = 0ms, Maximum = 0ms, Average = 0ms
```

Everything ping successfully.