NANYANG TECHNOLOGICAL UNIVERSITY SINGAPORE

NTU IOT RESEARCH GROUP

WANDS wireless and networked distributed sensing group

CE3005 Computer Networks

Part 2 - Tutorial 2 Network Layer - IP Routing and Routing Protocols

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if you have questions

[Last Week] Bonus Question

Why would you want a large MTU?

-> less overhead

Why not?

-> higher memory burden (low power device, or high link speed)

-> [Student] Reliability: smaller fragments have a lower chance to fail, or if they fail, less data has to be re-transmitted

-> It this a valid argument?

[Last Week] Bonus Question

#	Layer Name	Protocol	Protocol Data Unit	Addressing
5	Application	HTTP, SMTP, etc..	Messages	n/a
4	Transport	TCP/UDP	Segment	Port #'s
3	Network	IP	Datagram	IP address
2	Data Link	Ethernet, Wi-Fi	Frames	MAC Address
1	Physical	10 Base T, 802.11	Bits	n/a

https://www.parthshandilya.com

Not really: IP is best-effort

-> if one fragment fails, the re-assembly fails -> the whole packet gets dropped

-> IP layer does not re-transmit

TCP: the whole IP packet gets retransmitted

UDP: the whole IP packet gets discarded (and ignored)

Q1

1. Consider three hub-based Ethernets being interconnected by a transparent switch as shown in Figure Q1. Assume that all ARP caches and the switch forwarding table are initially empty.

   Suppose that a user at Station A issues a command *ping 192.168.222.222*. Using a table similar to Table Q1, list the sequence of Ethernet frames that are being sent and received at Station A, the purposes of the frames (e.g. Ping request for 192.168.222.222), and the actions taken by the transparent switch upon receiving the frames.

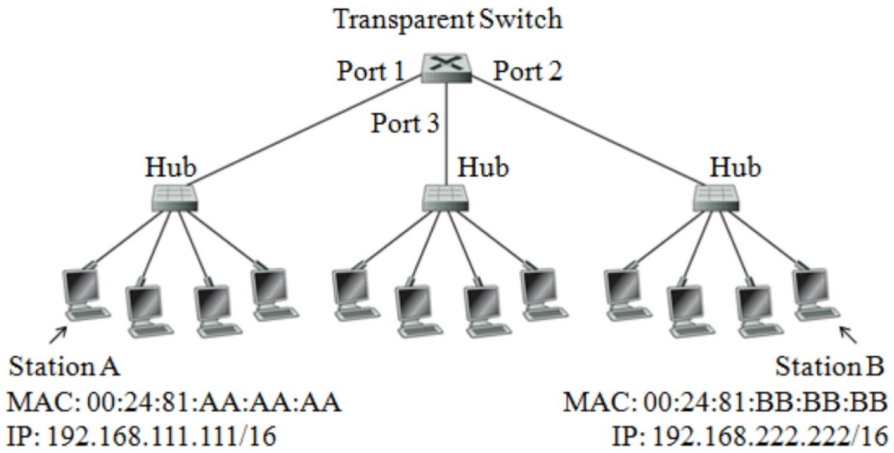

Figure Q1

Table Q1

	MAC address		Purpose of Frame	Actions taken by the Switch
Frame	Source	Destination		
1.				
2.				
...				

Q: Which TCP/IP layer are we operating here?

Q: Which TCP/IP layer are we operating on?

#	*Layer Name*	*Protocol*	*Protocol Data Unit*	*Addressing*
5	Application	HTTP, SMTP, etc..	Messages	n/a
4	Transport	TCP/UDP	Segment	Port #'s
3	Network	IP	Datagram	IP address
2	Data Link	Ethernet, Wi-Fi	Frames	MAC Address
1	Physical	10 Base T, 802.11	Bits	n/a

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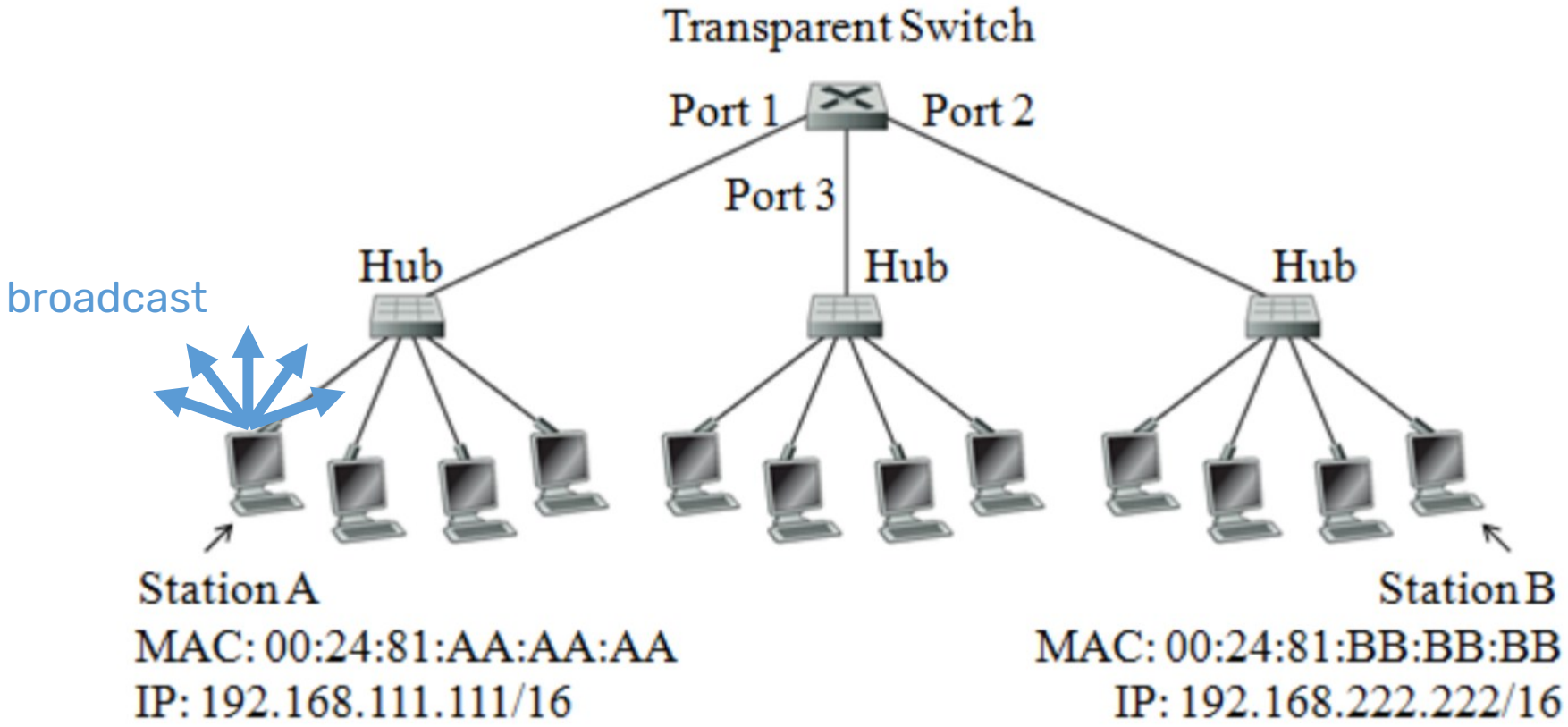
Q: Which TCP/IP layer are we operating on?

#	Layer Name	Protocol	Protocol Data Unit	Addressing
5	Application	HTTP, SMTP, etc..	Messages	n/a
4	Transport	TCP/UDP	Segment	Port #'s
3	Network	IP	Datagram	IP address
2	Data Link	Ethernet, Wi-Fi	Frames	MAC Address
1	Physical	10 Base T, 802.11	Bits	n/a

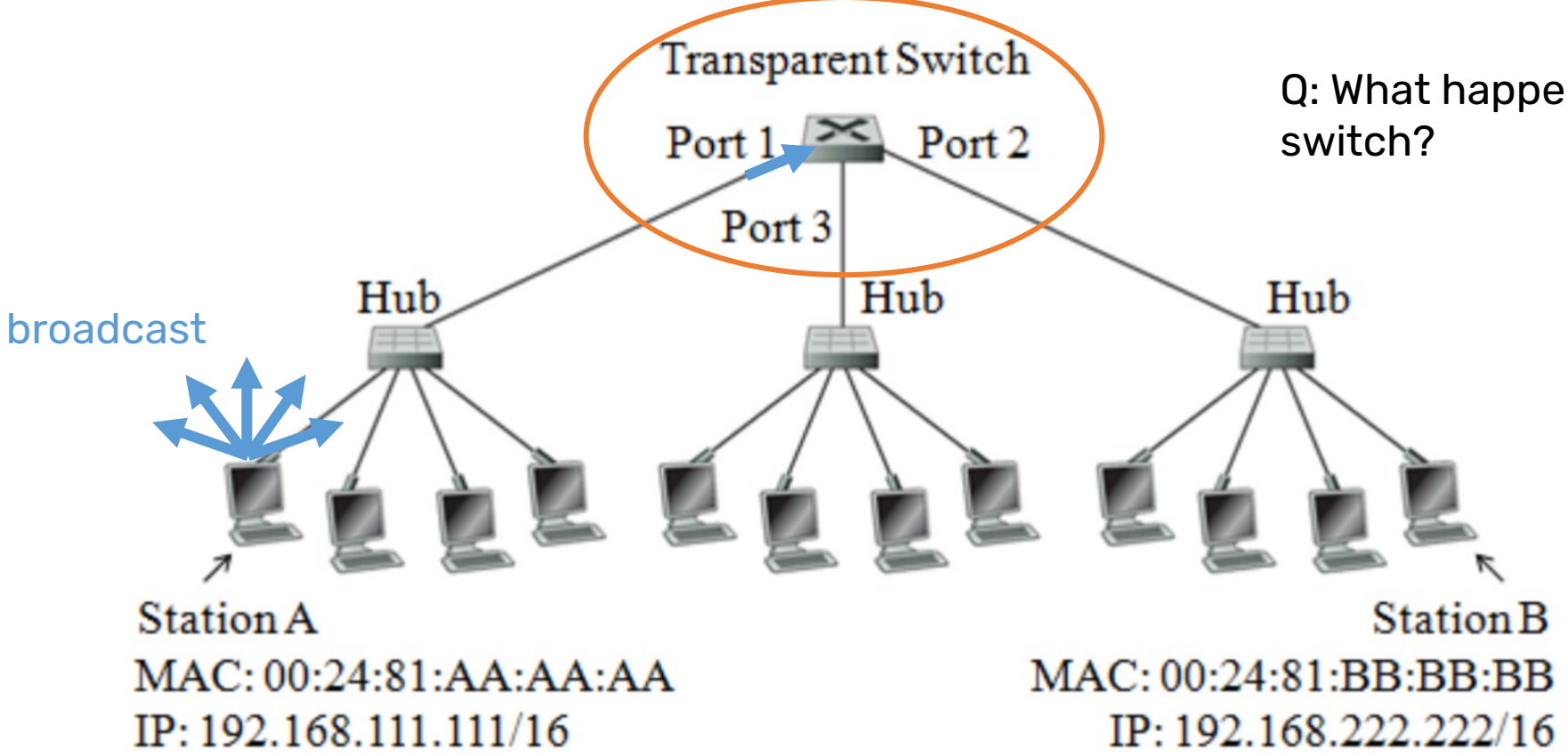
https://www.parthshandilya.com

Q1



Frame			Purpose of Frame	Actions taken by Switch
	Source	Destination		
1.	00-24-81-AA-AA-AA	???	ARP request for 192.168.222.222	

Q1

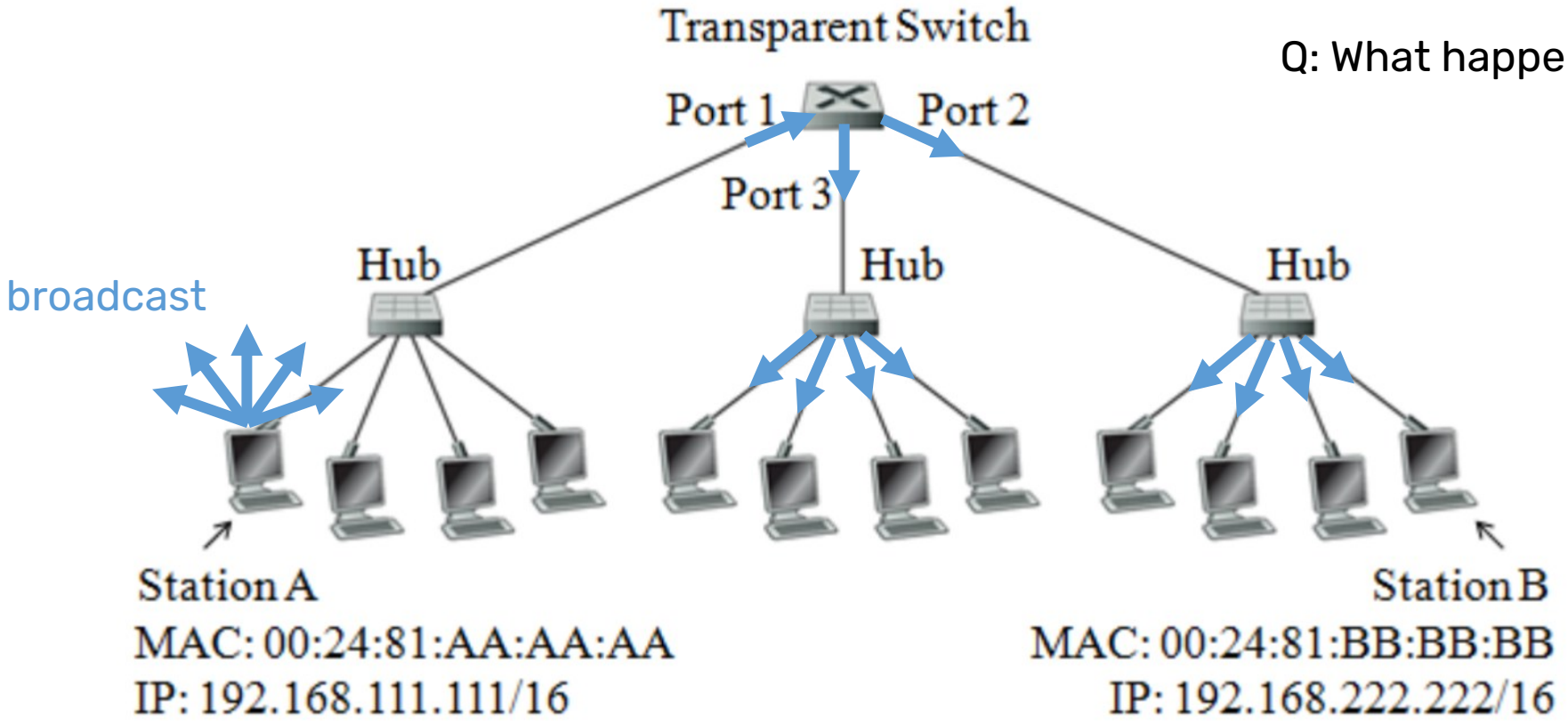


Q: What happens at the switch?

Frame			Purpose of Frame	Actions taken by Switch
	Source	Destination		
1.	00-24-81-AA-AA-AA	FF-FF-FF-FF-FF-FF	ARP request for 192.168.222.222	

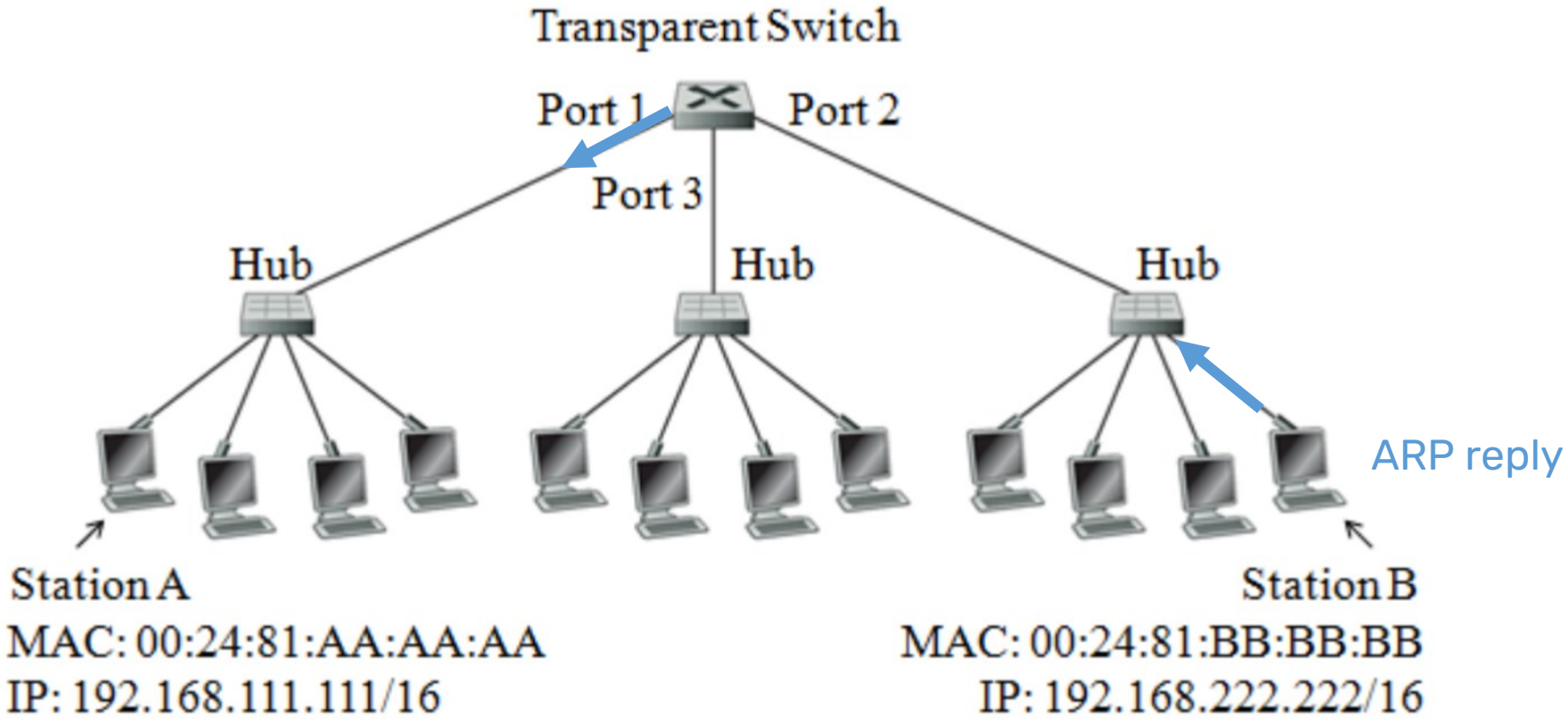
Q1

Q: What happens next?



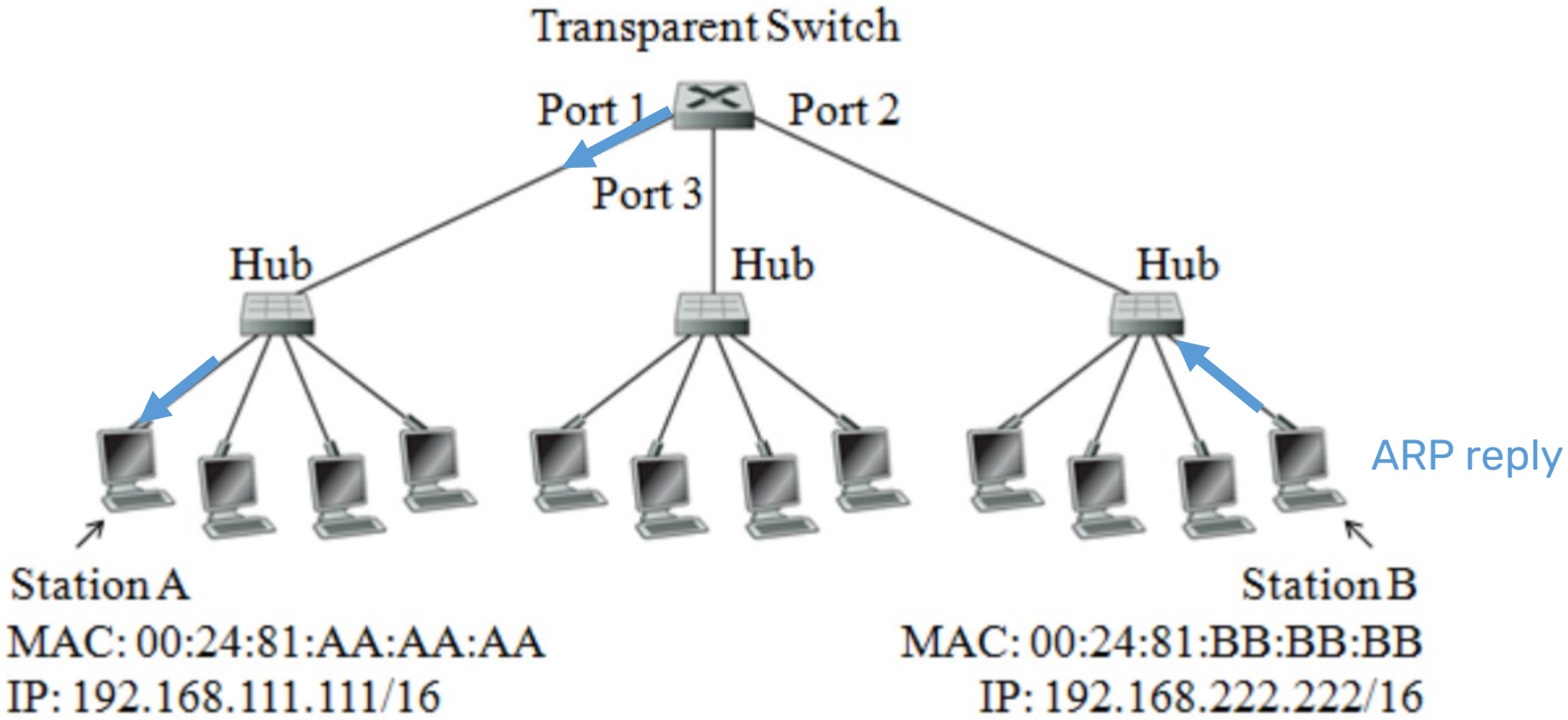
Frame			Purpose of Frame	Actions taken by Switch
	Source	Destination		
1.	00-24-81-AA-AA-AA	FF-FF-FF-FF-FF-FF	ARP request for 192.168.222.222	- new entry forwarding table 00-24-81-AA-AA-AA/port 1/ time - broadcast ARP request frame to both port 2, 3

Q1



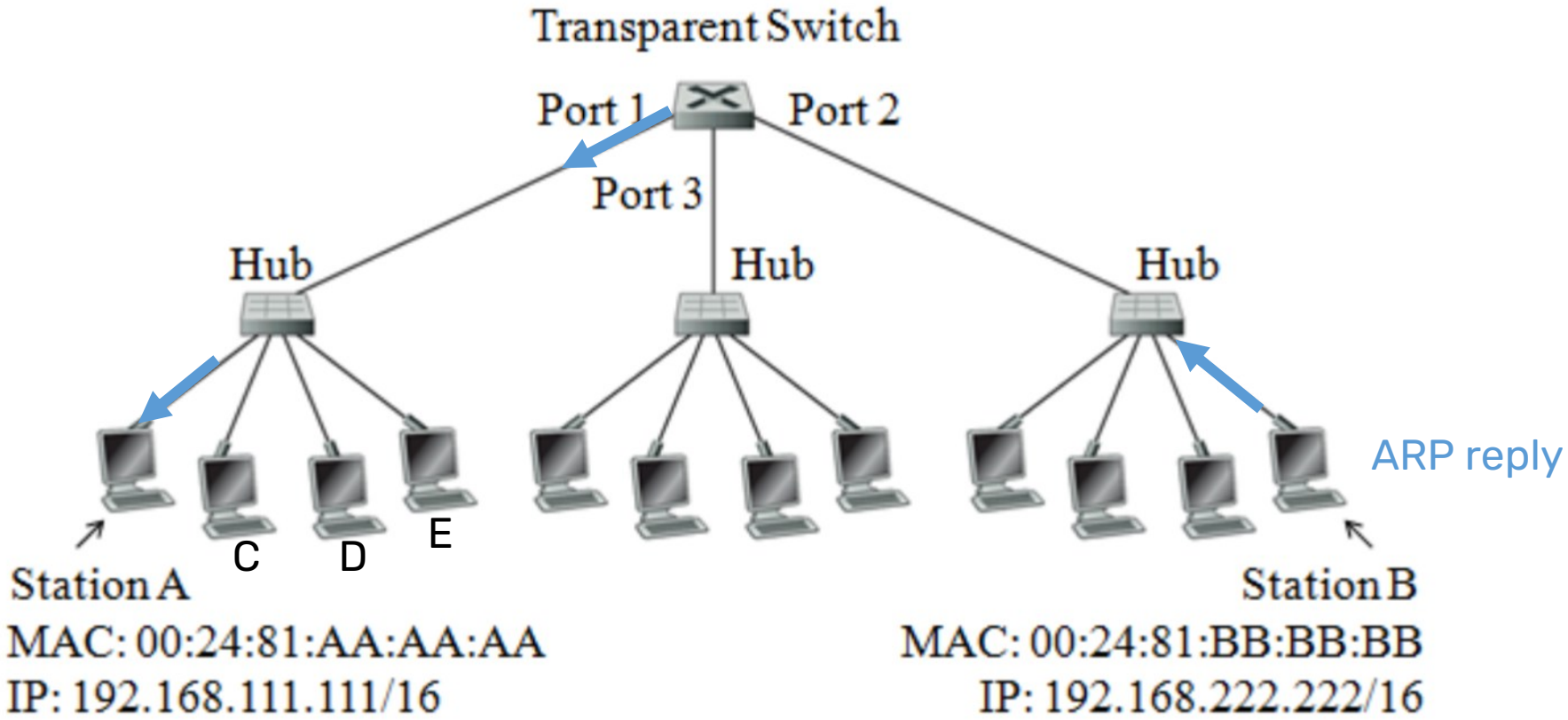
Frame			Purpose of Frame	Actions taken by Switch
	Source	Destination		
2.	00-24-81-BB-BB-BB	???	ARP reply	- new entry forwarding table 00-24-81-BB-BB-BB/port 2/ time - forward ARP reply to port 1

Q1



Frame			Purpose of Frame	Actions taken by Switch
	Source	Destination		
2.	00-24-81-BB-BB-BB	00-24-81-AA-AA-AA	ARP reply	- new entry forwarding table 00-24-81-BB-BB-BB/port 2/ time - forward ARP reply to port 1

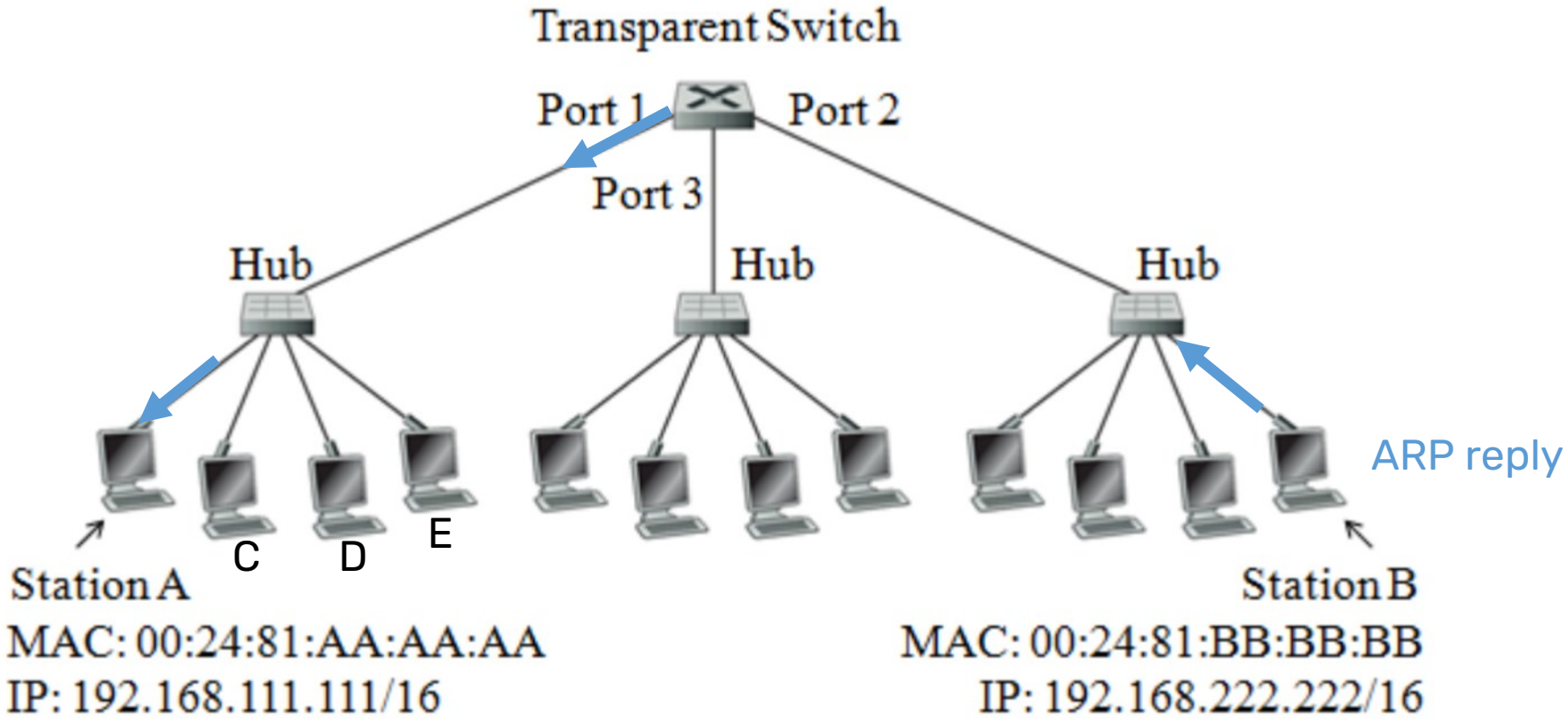
Q1



Q: Who gets the response?

Only station A? Or also C/D/E?

Q1



It depends. Generally, the reply is unicast, but..

-> Hub based systems -> devices are allowed to also record it (ARP cache learning)
-> Modern switches (L2) usually prevent unicast replies from being flooded to all ports (so, only the requester sees it)
-> WiFi is typically broadcast (like the hub)

Q1

Frame	MAC Address		Purpose of Frame	Actions taken by Switch
	Source	Destination		
3.	00-24-81-AA-AA-AA	00-24-81-BB-BB-BB	ping request for 192.168.222.222	- update forwarding table 00-24-81-AA-AA-AA/port 1/ new time - forward ping request to port 2
4.	00-24-81-BB-BB-BB	00-24-81-AA-AA-AA	ping reply	- update forwarding table 00-24-81-BB-BB-BB/port 2/ new time - forward ping reply to port 1

For simplicity, assume ping sends 1 packet instead of 4.

Q2

2. Now consider the three hub-based Ethernets being interconnected by a router, which is configured as the default gateway for all stations as shown in Figure Q2. Assume that all ARP caches are initially empty.

Similarly, suppose that a user at Station A issues a command *ping 192.168.222.222*. Using a table similar to Table Q2, list the sequence of Ethernet frames that are being sent and received at Station A, the purposes of the frames (e.g. Ping request for 192.168.222.222), and the actions taken by the router upon receiving the frames.

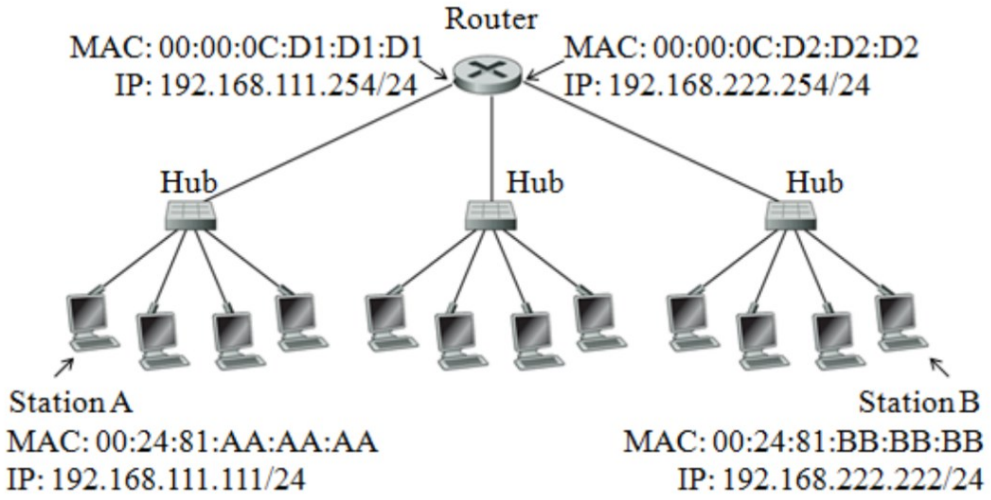


Figure Q2

Table Q2

	MAC address		Purpose of Frame	Actions taken by the Router
Frame	Source	Destination		
1.				
2.				
...				

Q: What's different to Q1?

Q2: What's different to Q1?

Station A and B are in separate networks..

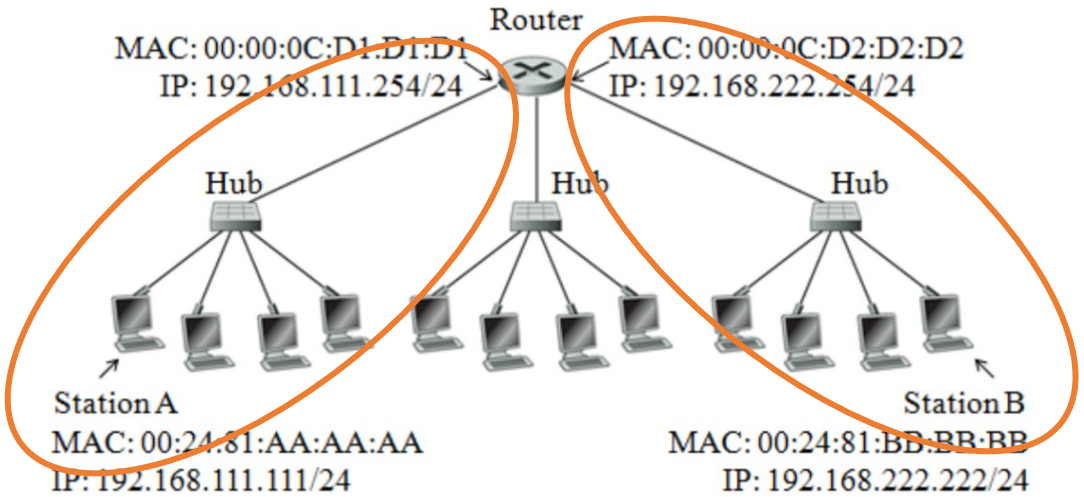


Figure Q2

#	Layer Name	Protocol	Protocol Data Unit	Addressing
5	Application	HTTP, SMTP, etc..	Messages	n/a
4	Transport	TCP/UDP	Segment	Port #'s
3	Network	IP	Datagram	IP address
2	Data Link	Ethernet, Wi-Fi	Frames	MAC Address
1	Physical	10 Base T, 802.11	Bits	n/a

L3 and L2 are now involved..

Q2

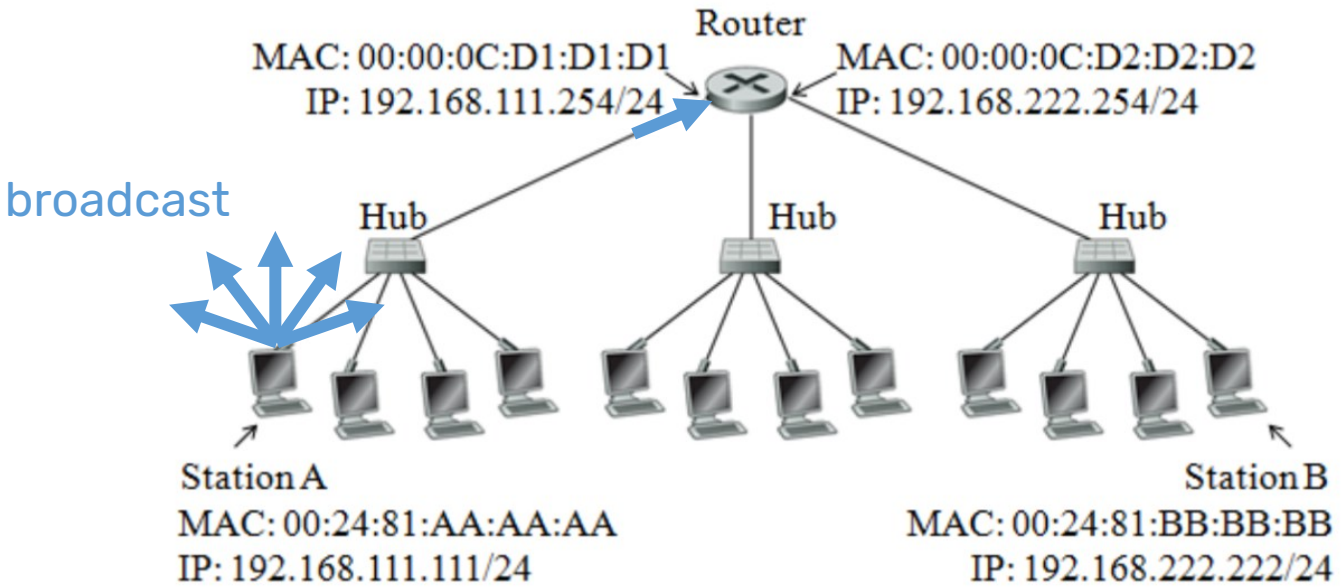


Figure Q2

Q: What happens next?
Who will answer?

Frame	MAC Address		Purpose of Frame	Actions taken by Router
	Source	Destination		
1.	00-24-81-AA-AA-AA	FF-FF-FF-FF-FF-FF		

Q2

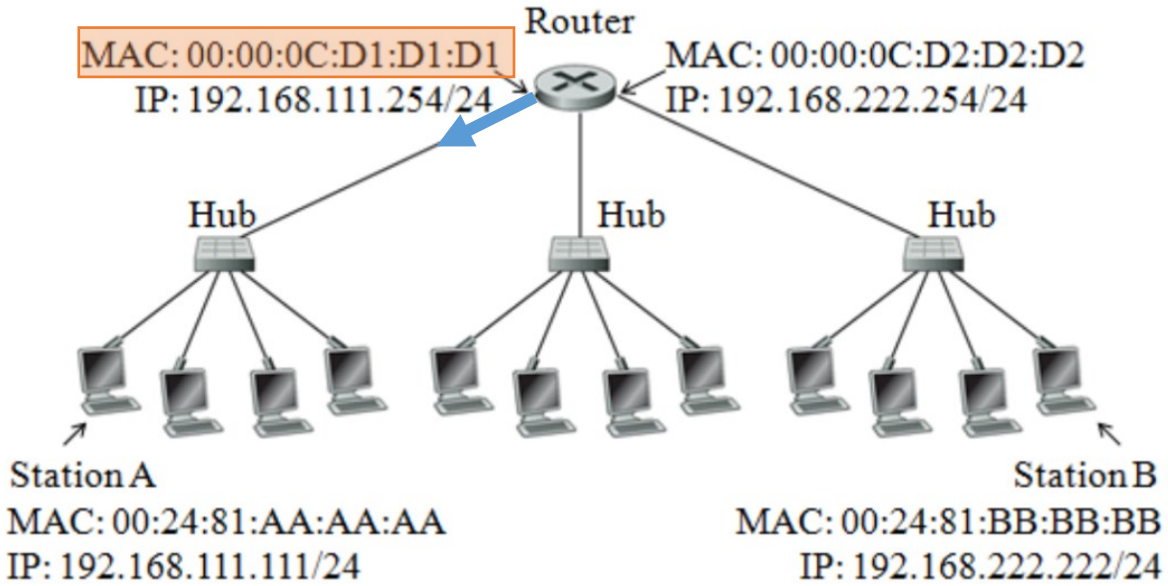


Figure Q2

A: The default gateway

Frame	MAC Address		Purpose of Frame	Actions taken by Router
	Source	Destination		
2.	00-00-0C-D1-D1-D1	00-24-81-AA-AA-AA	ARP reply	- send ARP reply

Q2

ping request for
192.168.222.222

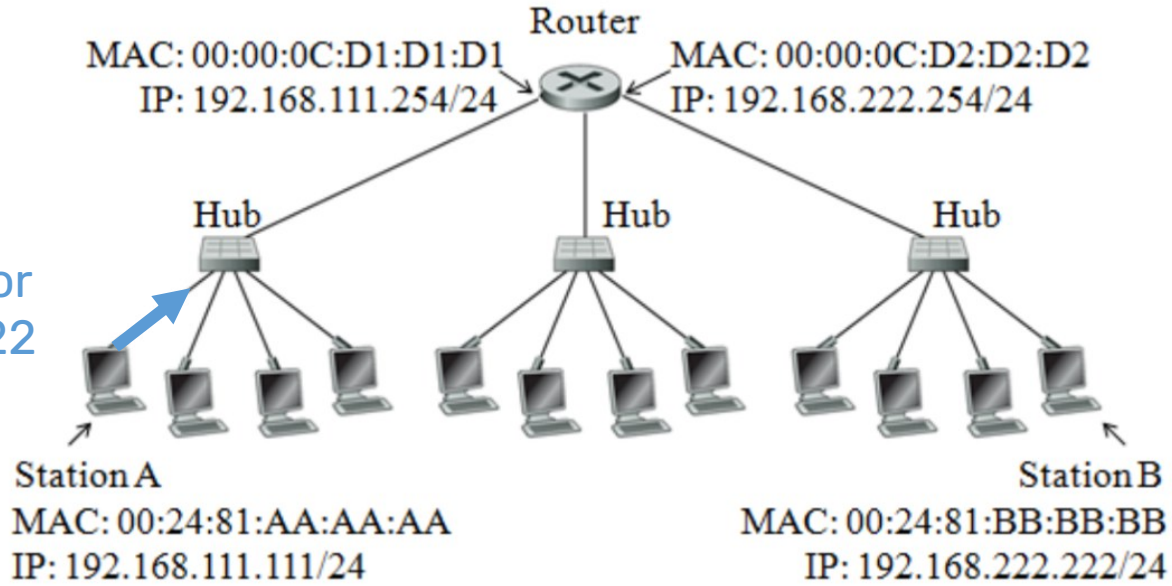


Figure Q2

Q: What happens now?

Q2

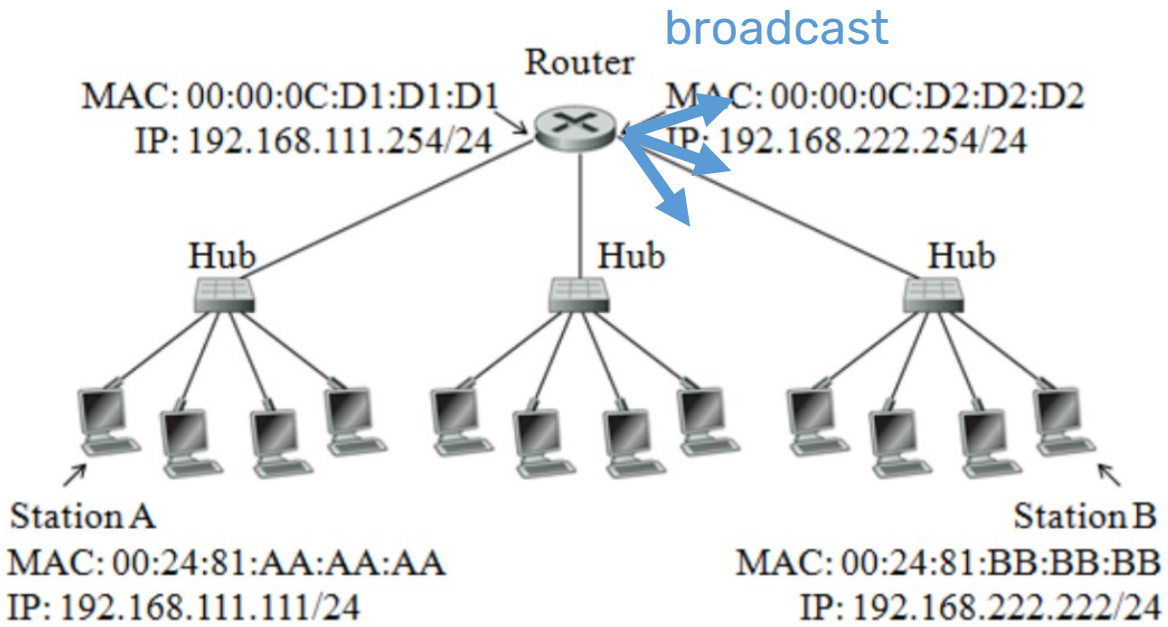


Figure Q2

Frame	MAC Address		Purpose of Frame	Actions taken by Router
	Source	Destination		
3.	00-24-81-AA-AA-AA	00-00-0C-D1-D1-D1	ping request for 192.168.222.222	- broadcast ARP request for 192.168.222.222 at subnet 192.168.222.0/24

Q2

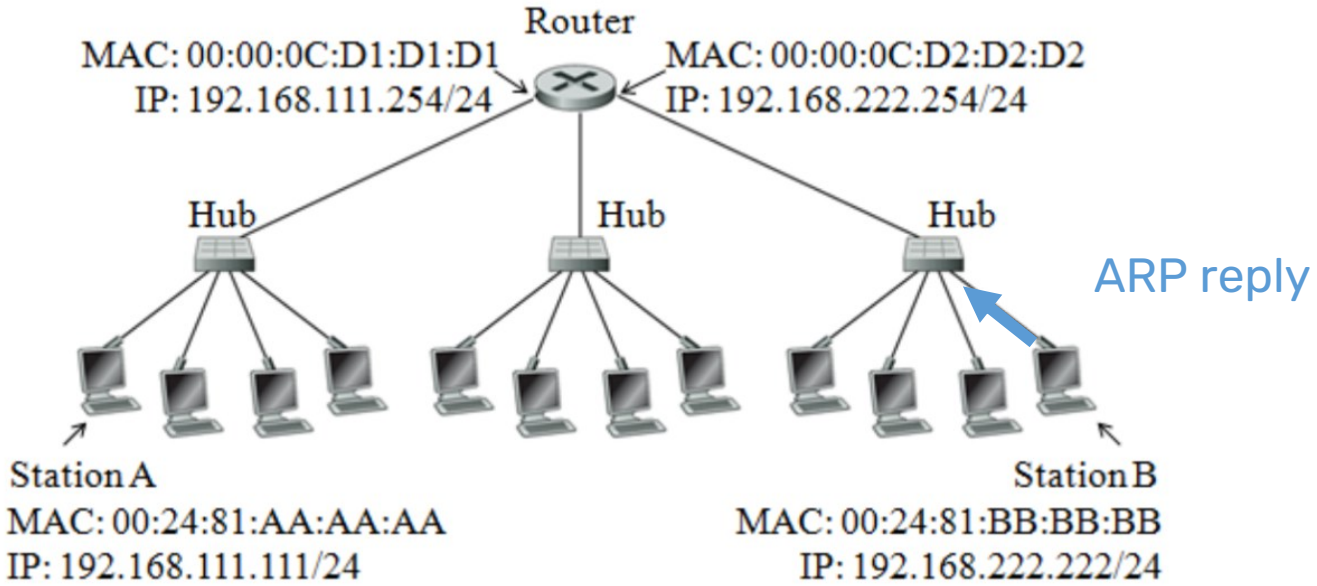


Figure Q2

Frame	MAC Address		Purpose of Frame	Actions taken by Router
	Source	Destination		
3.	00-24-81-AA-AA-AA	00-00-0C-D1-D1-D1	ping request for 192.168.222.222	- broadcast ARP request for 192.168.222.222 at subnet 192.168.222.0/24 - receive ARP reply

Q2

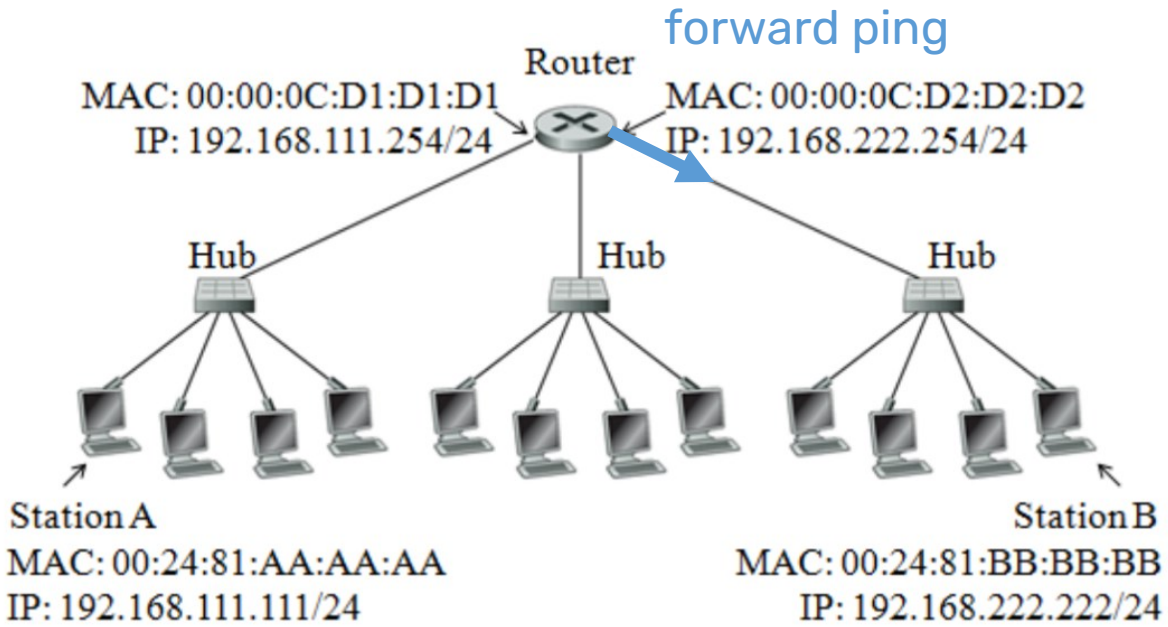


Figure Q2

Frame	MAC Address		Purpose of Frame	Actions taken by Router
	Source	Destination		
3.	00-24-81-AA-AA-AA	00-00-0C-D1-D1-D1	ping request for 192.168.222.222	- broadcast ARP request for 192.168.222.222 at subnet 192.168.222.0/24 - receive ARP reply - new entry ARP cache 192.168.222.222/00-24-81-BB-BB-BB - forward ping request to 192.168.222.222

Q2

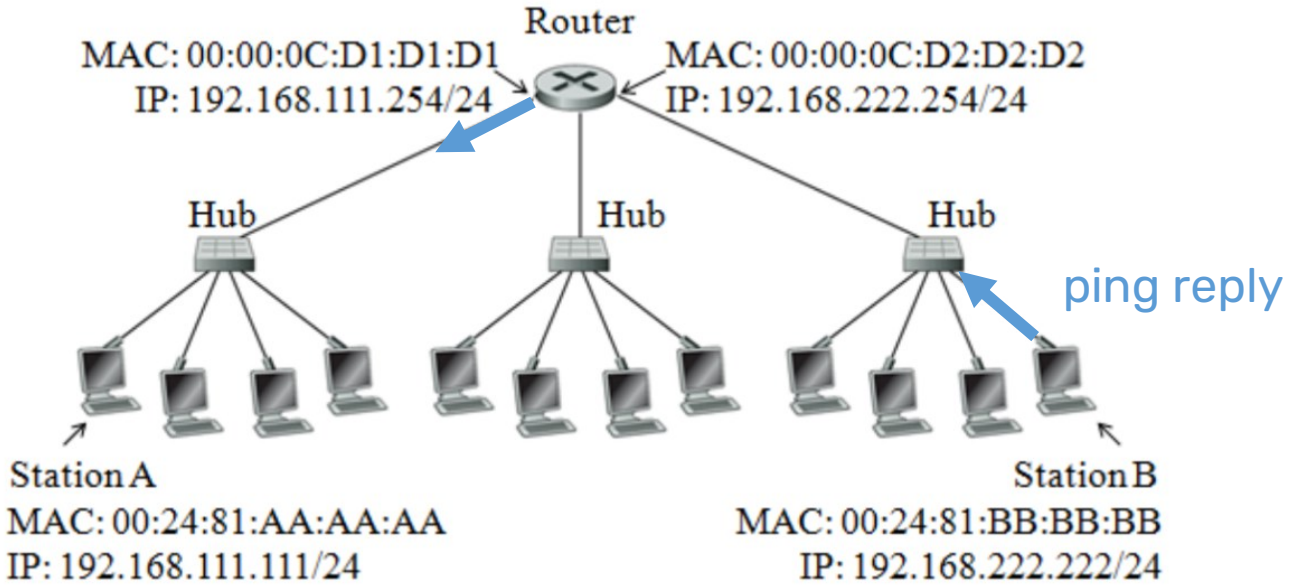


Figure Q2

Frame	MAC Address		Purpose of Frame	Actions taken by Router
	Source	Destination		
4.	00-00-0C-D1-D1-D1	00-24-81-AA-AA-AA	ping reply	- receive ping reply - forward ping reply to 192.168.111.111

For simplicity, assume ping sends 1 packet instead of 4.

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Q2 - Hands-On [MS Windows]

ipconfig

```
Ethernet adapter Ethernet 3:

   Connection-specific DNS Suffix  . :
   IPv4 Address. . . . . . . . . . . : 192.168.0.108
   Subnet Mask . . . . . . . . . . . : 255.255.255.0
   Default Gateway . . . . . . . . . : 192.168.0.1
```

arp -a

netsh interface ip delete arpcache

ping X

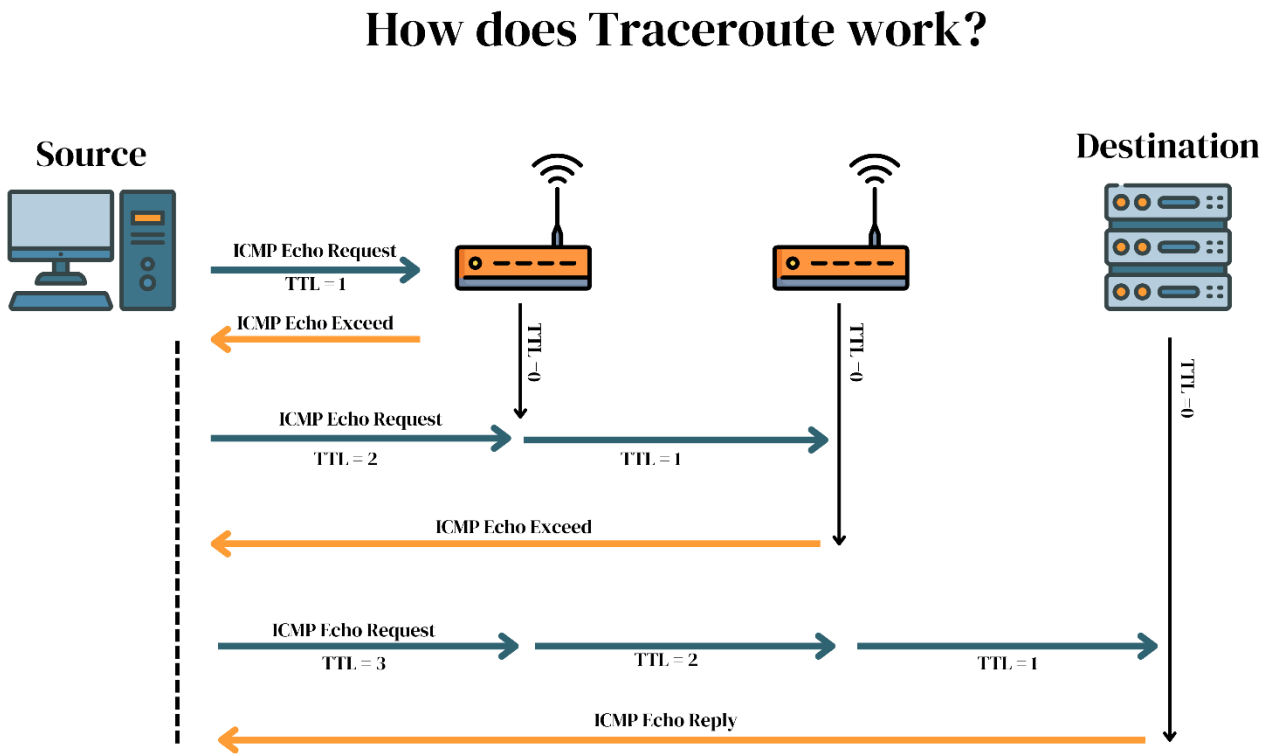
```
Interface: 192.168.0.108 --- 0x15
  Internet Address      Physical Address      Type
  192.168.0.1           30-b[redacted]        dynamic
  192.168.0.101         c0-2[redacted]        dynamic
  192.168.0.103         bc-d[redacted]        dynamic
  192.168.0.255         ff-ff-ff-ff-ff-ff     static
  224.0.0.22            01-00-5e-00-00-16     static
  224.0.0.251           01-00-5e-00-00-fb     static
  224.0.0.252           01-00-5e-00-00-fc     static
  239.255.255.250       01-00-5e-7f-ff-fa     static
  255.255.255.255       ff-ff-ff-ff-ff-ff     static

Interface: 172.28.16.1 --- 0x2f
  Internet Address      Physical Address      Type
  172.28.21.37          00-1[redacted]        dynamic
  172.28.31.255         ff-f[redacted]        static
  224.0.0.22            01-0[redacted]        static
  224.0.0.251           01-00-5e-00-00-fb     static
  239.255.255.250       01-00-5e-7f-ff-fa     static
```

Q3

3. The following table shows the results of three trace-routes. Based on the information, draw the network topology. Show clearly the IP addresses of all networks.

From Station A to B	From Station C to A	From Station B to C
155.69.8.10	200.20.80.12	196.19.5.104
10.203.20.10	170.105.10.21	130.21.80.90
130.21.10.30	80.90.10.3	90.80.120.10
196.19.5.5	155.69.8.12	170.105.10.20
		200.20.80.15

Q2



ClouDNS

https://www.cloudns.net

Q3

Group 1

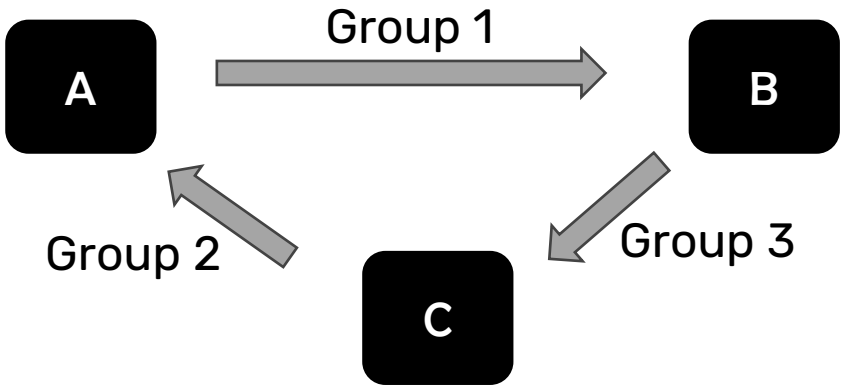
From Station A to B
155.69.8.10
10.203.20.10
130.21.10.30
196.19.5.5

Group 2

From Station C to A
200.20.80.12
170.105.10.21
80.90.10.3
155.69.8.12

Group 3

From Station B to C
196.19.5.104
130.21.80.90
90.80.120.10
170.105.10.20
200.20.80.15



Q: Which networks are our packets traveling through?

i.e. **155.69.8.x**

Q3

Group 1

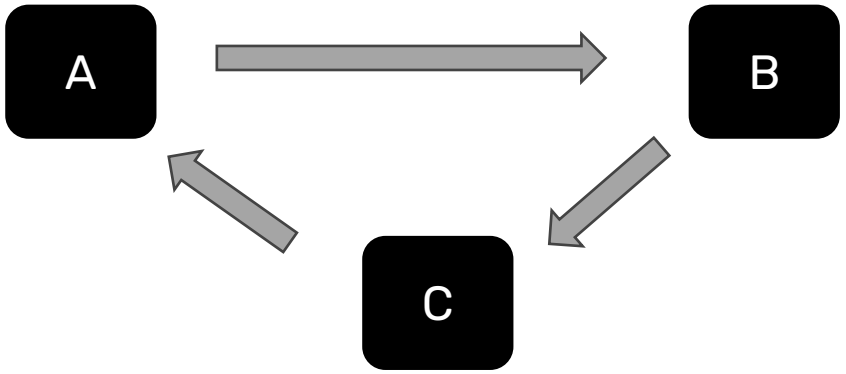
From Station A to B
155.69.8.10
10.203.20.10
130.21.10.30
196.19.5.5

Group 2

From Station C to A
200.20.80.12
170.105.10.21
80.90.10.3
155.69.8.12

Group 3

From Station B to C
196.19.5.104
130.21.80.90
90.80.120.10
170.105.10.20
200.20.80.15



155.69.8.x

10.203.20.x

130.21.x.x

196.19.5.x

200.20.80.x

170.105.10.x

80.90.10.x

90.80.120.x

Q3: Group Work: Draw the Diagram

Group 1

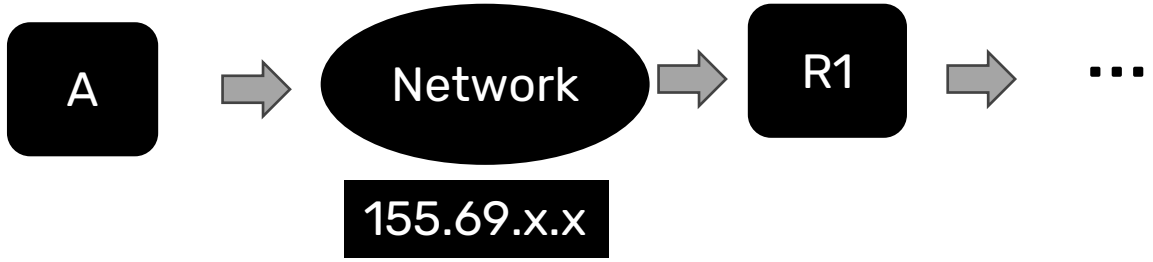
From Station A to B
155.69.8.10
10.203.20.10
130.21.10.30
196.19.5.5

Group 2

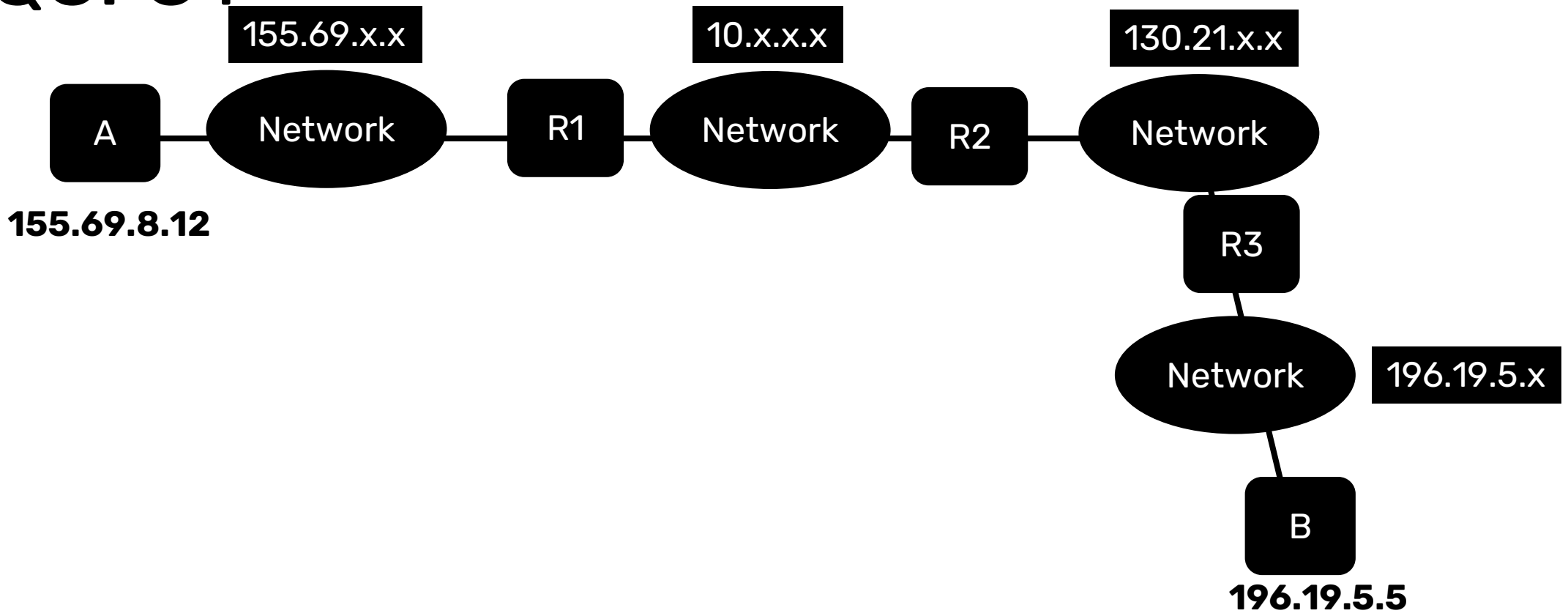
From Station C to A
200.20.80.12
170.105.10.21
80.90.10.3
155.69.8.12

Group 3

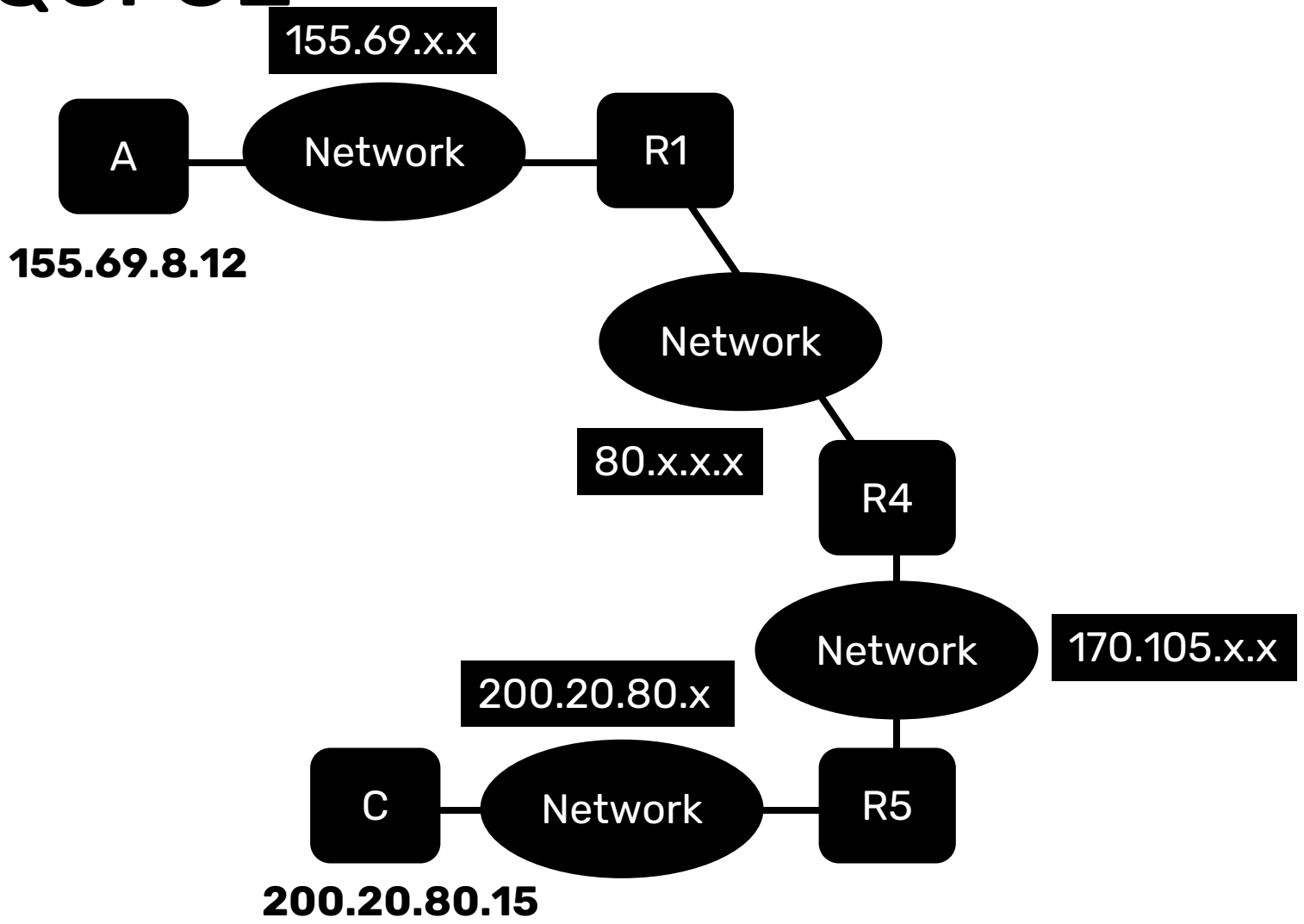
From Station B to C
196.19.5.104
130.21.80.90
90.80.120.10
170.105.10.20
200.20.80.15



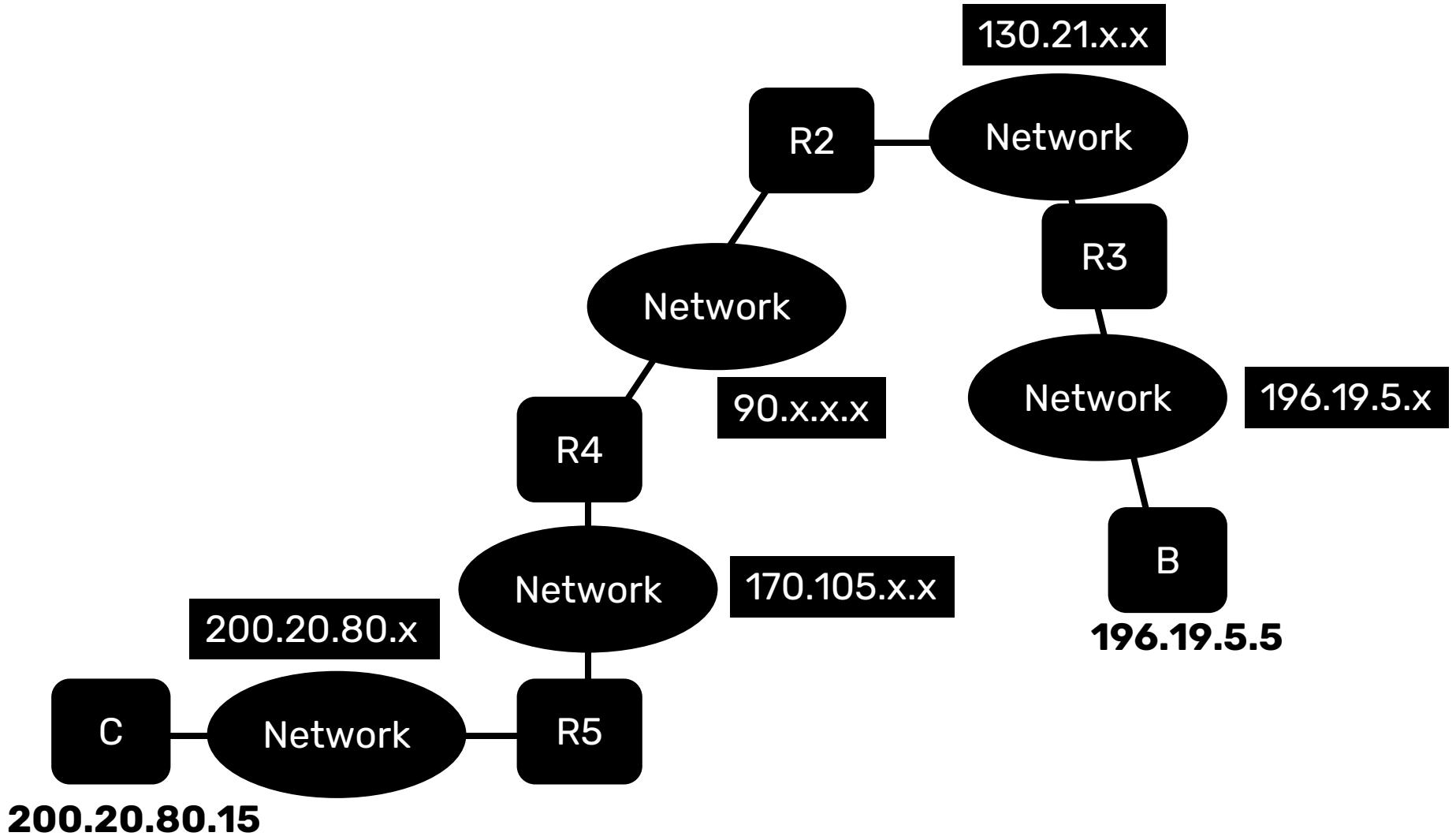
Q3: G1


155.69.x.x
10.x.x.x
130.21.x.x
A
Network
R1
Network
R2
Network
155.69.8.12
R3
Network
196.19.5.x
B
196.19.5.5

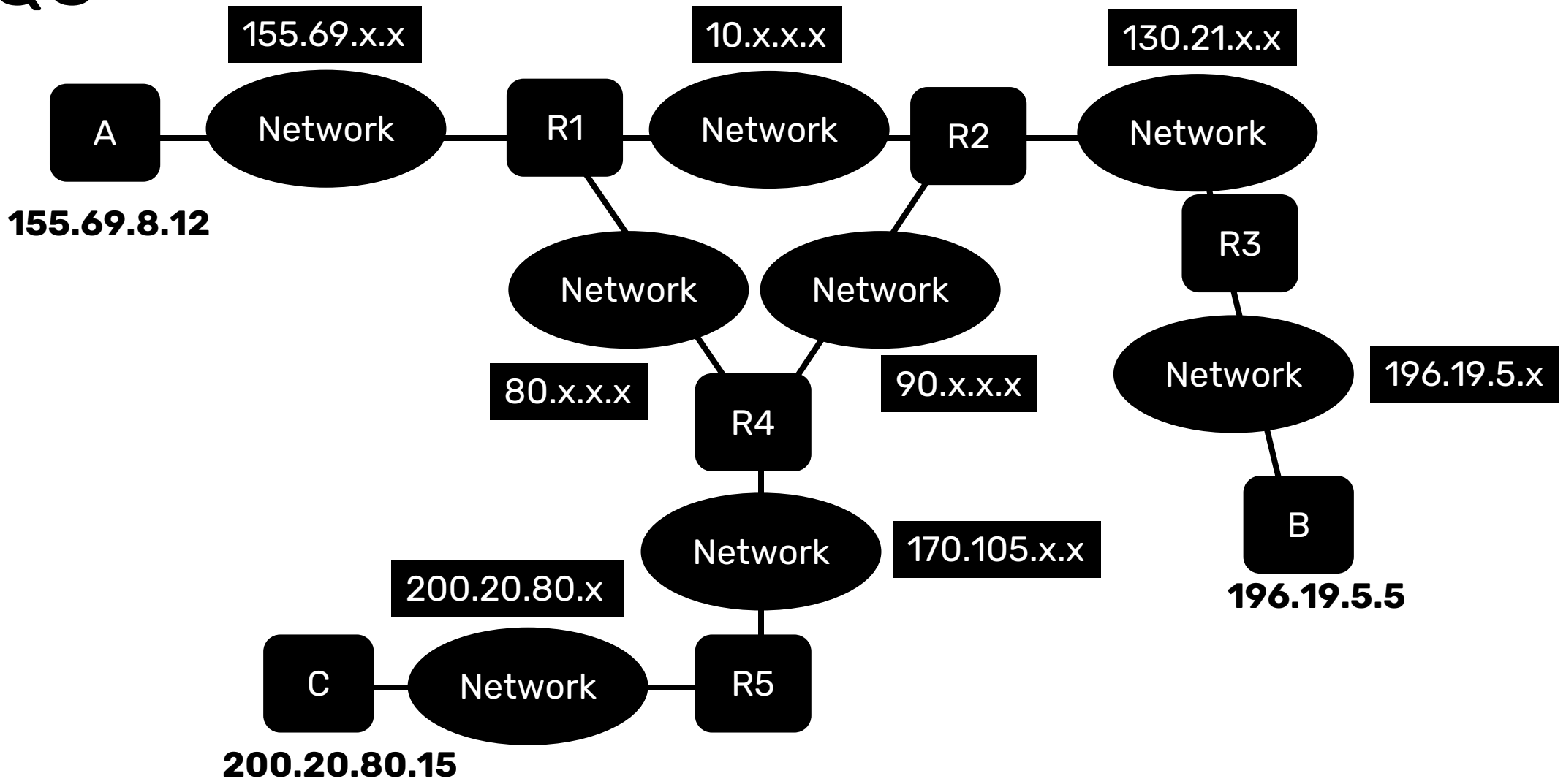
Q3: G2


155.69.x.x
A
Network
R1
155.69.8.12
Network
80.x.x.x
R4
Network
170.105.x.x
200.20.80.x
C
Network
R5
200.20.80.15

Q3: G3

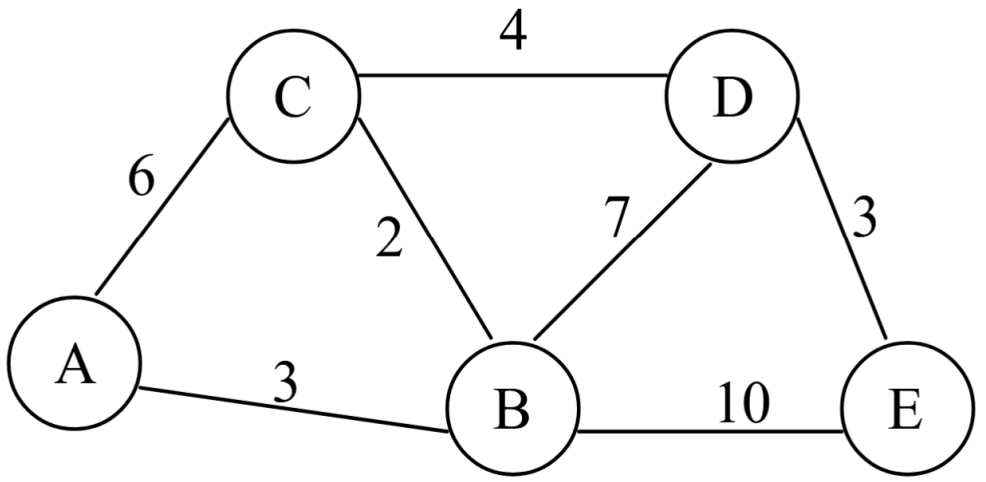

130.21.x.x
R2
Network
R3
Network
90.x.x.x
Network
196.19.5.x
R4
B
196.19.5.5
Network
170.105.x.x
200.20.80.x
C
Network
R5
200.20.80.15

Q3


155.69.x.x
10.x.x.x
130.21.x.x
A
Network
R1
Network
R2
Network
155.69.8.12
R3
Network
Network
80.x.x.x
90.x.x.x
Network
196.19.5.x
R4
B
Network
170.105.x.x
196.19.5.5
200.20.80.x
C
Network
R5
200.20.80.15

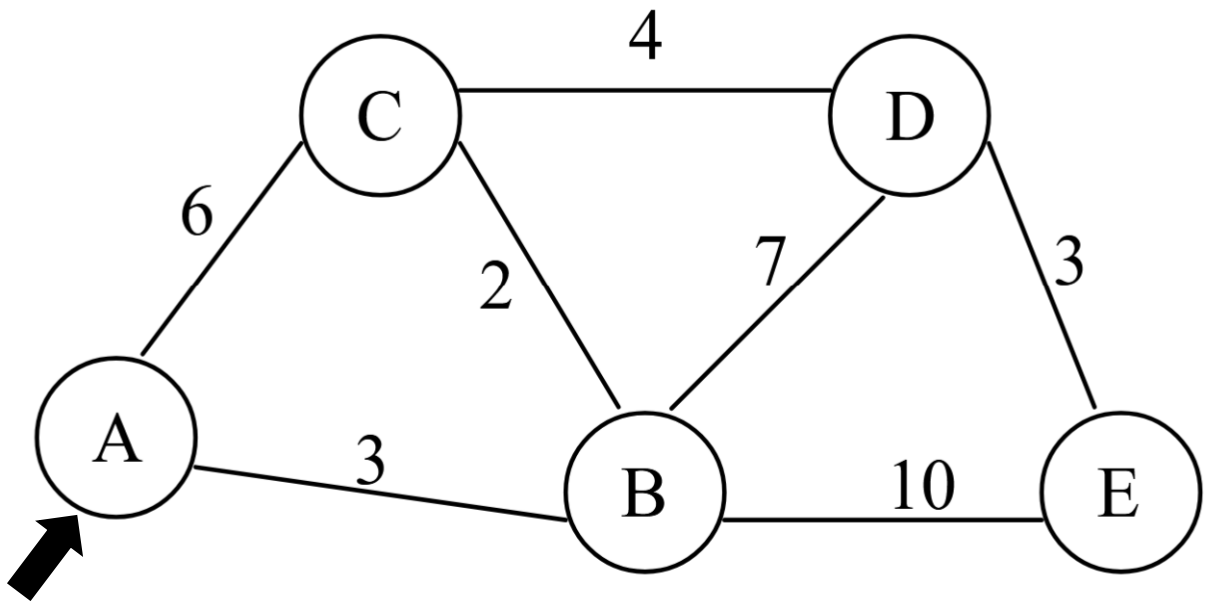
Q4

4. Using Dijkstra's algorithm, generate the least cost routes to all other nodes from the source node A in the following figure. The integer numbers in the figure represent the link costs.



distance

Q4



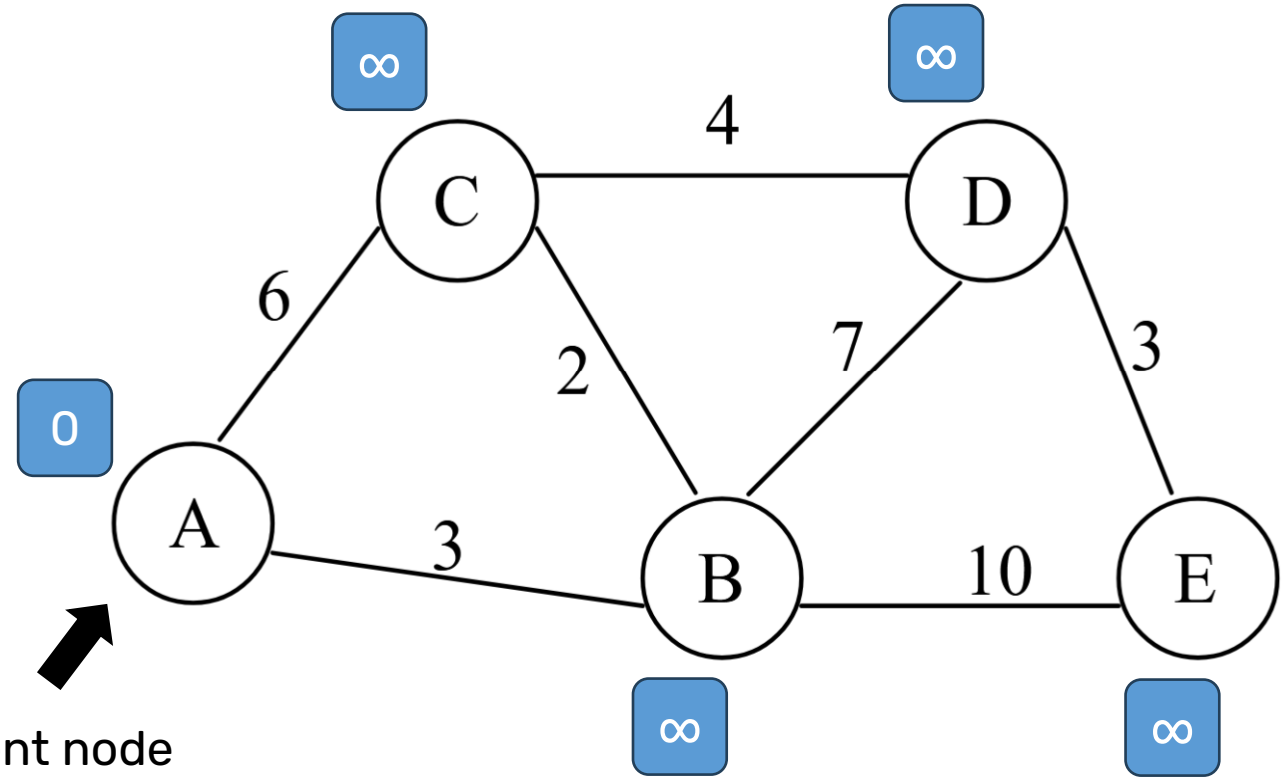
current node

visited: {}
not visited*: {A, B, C, D, E}

*sorted from smallest distance value to largest

distance

Q4

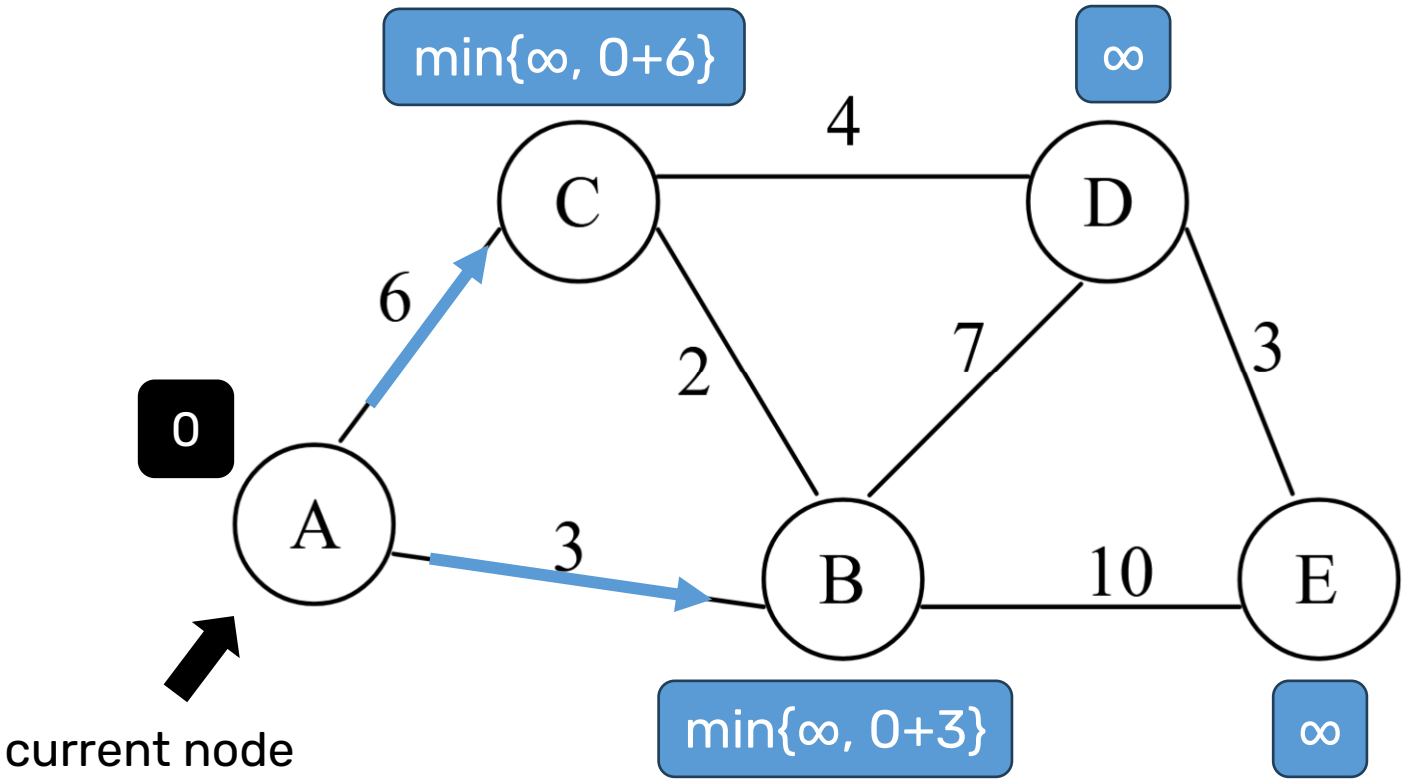


visited: {}
not visited*: {A, B, C, D, E}

*sorted from smallest distance value to largest

distance

Q4

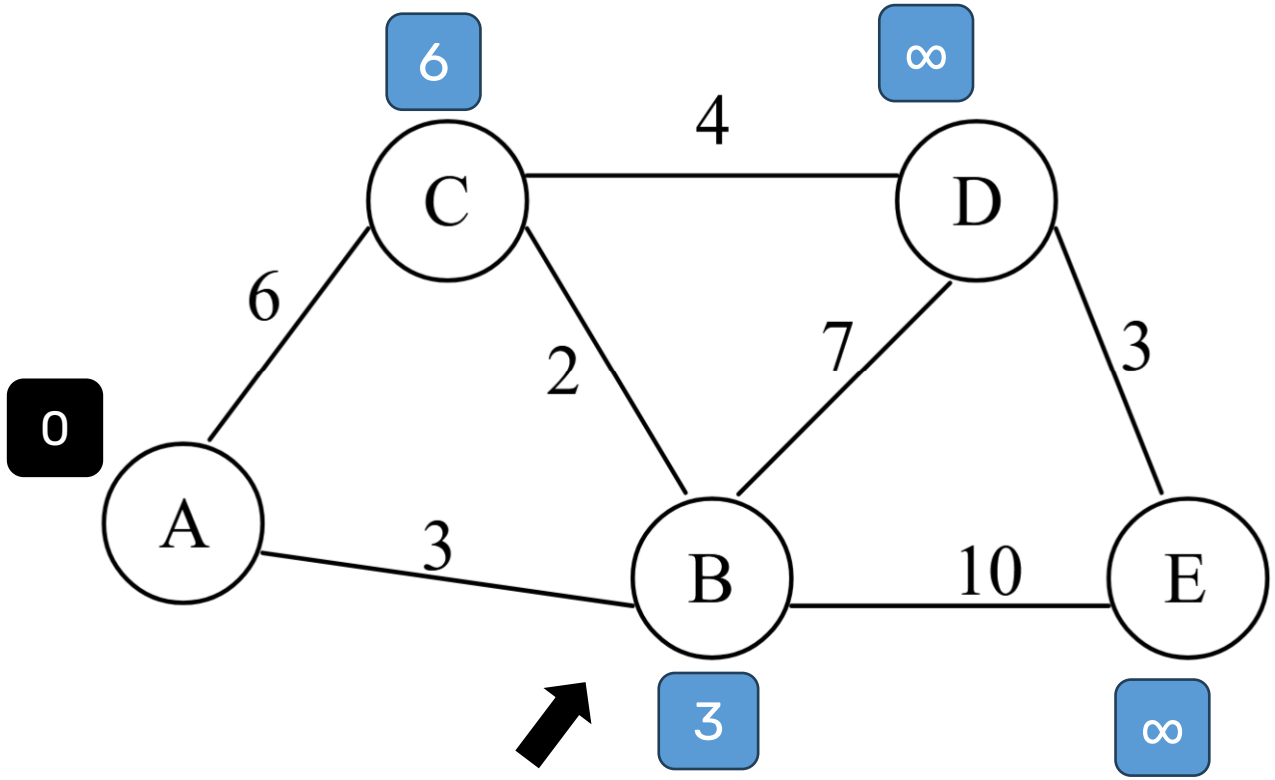


visited: {A}
not visited*: {B, C, D, E}

*sorted from smallest distance value to largest

distance

Q4

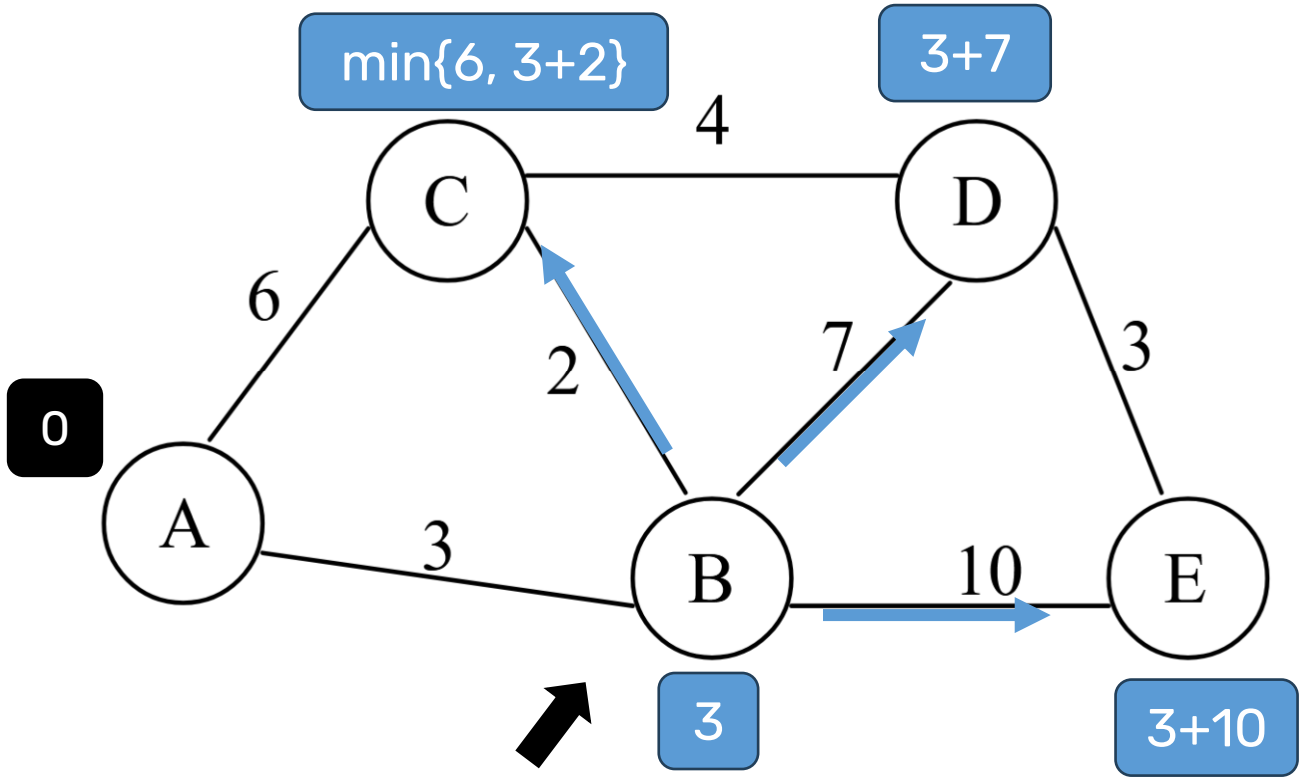


visited: {A}
not visited*: {B, C, D, E}

*sorted from smallest distance value to largest

distance

Q4

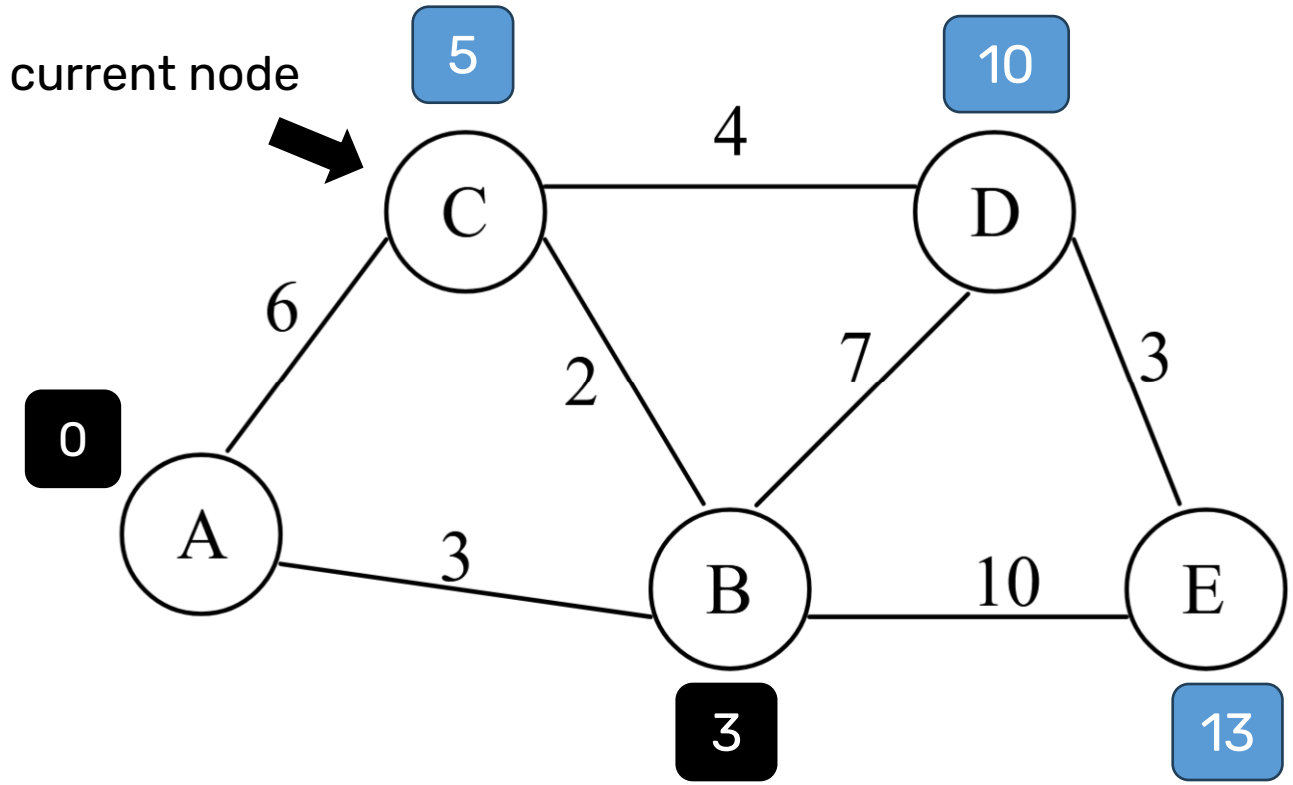


visited: {A}
not visited*: {B, C, D, E}

*sorted from smallest distance value to largest

distance

Q4

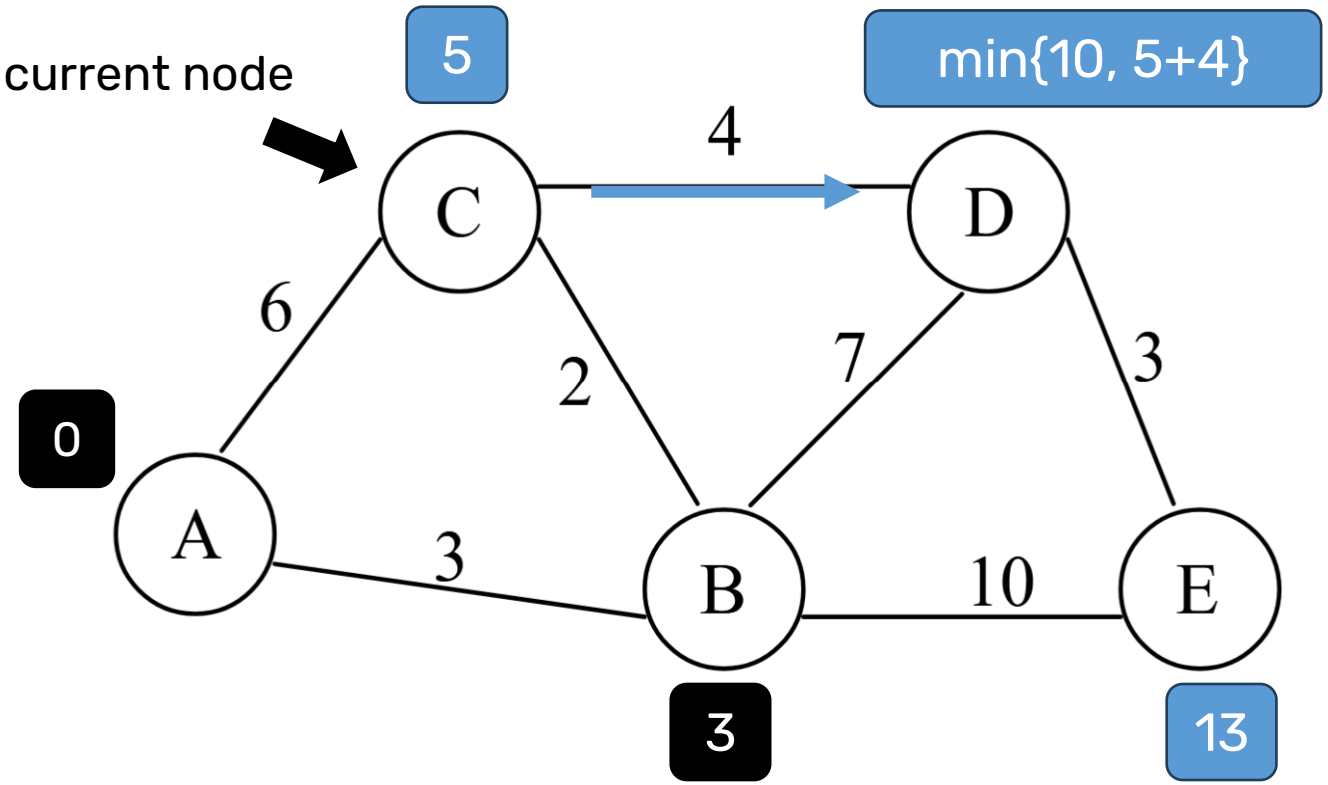


visited: {A, B}
not visited*: {C, D, E}

*sorted from smallest distance value to largest

distance

Q4

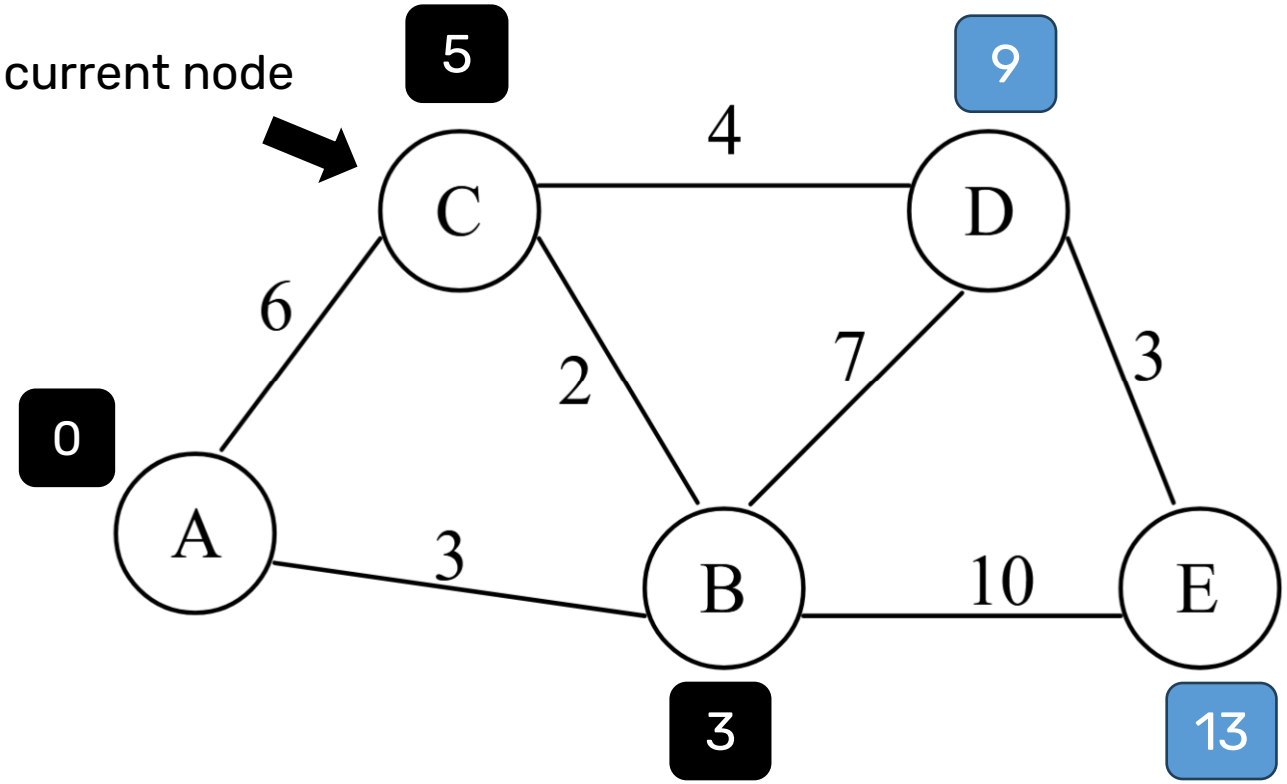


visited: {A, B}
not visited*: {C, D, E}

*sorted from smallest distance value to largest

distance

Q4

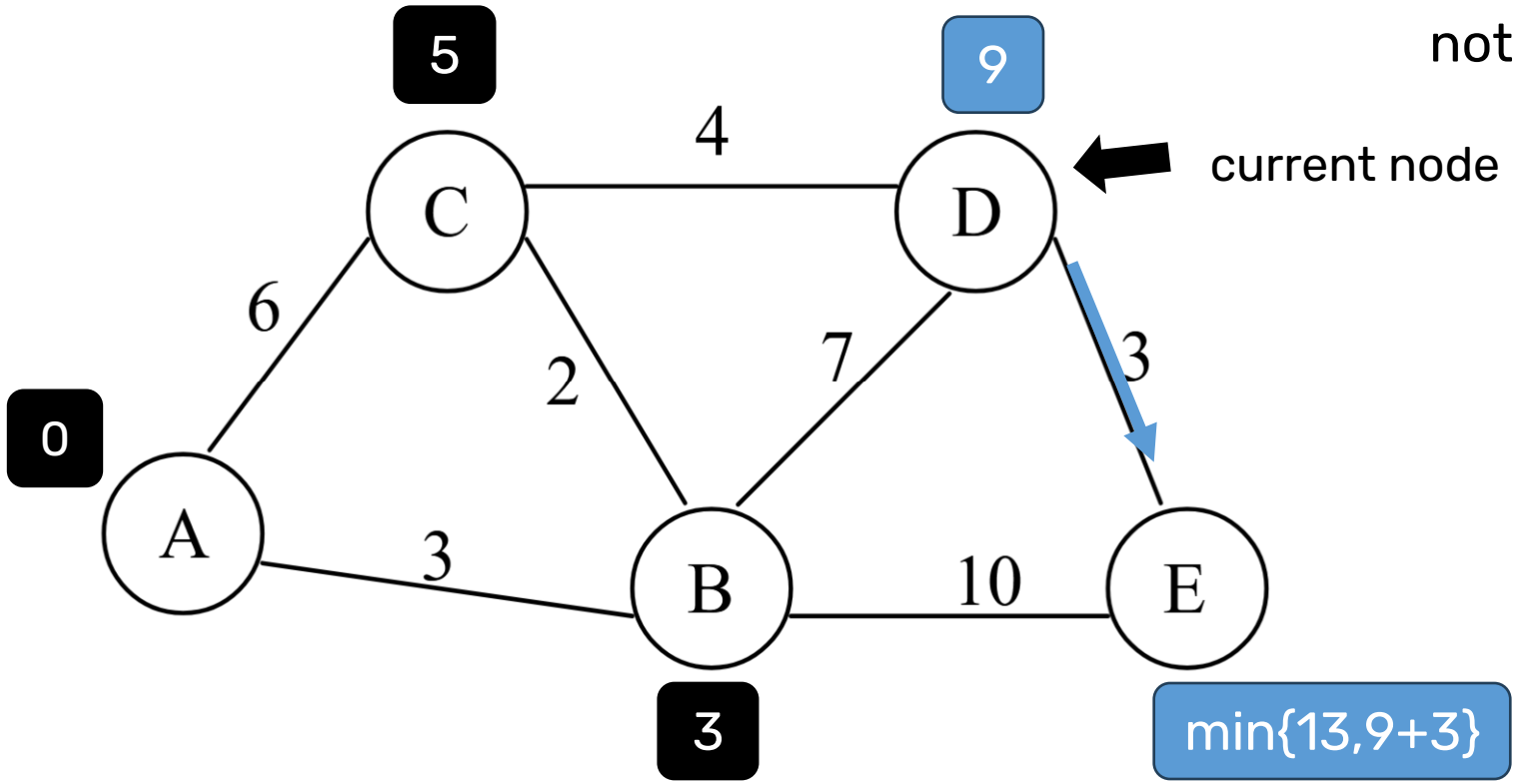


visited: {A, B, C}
not visited*: {D, E}

*sorted from smallest distance value to largest

distance

Q4

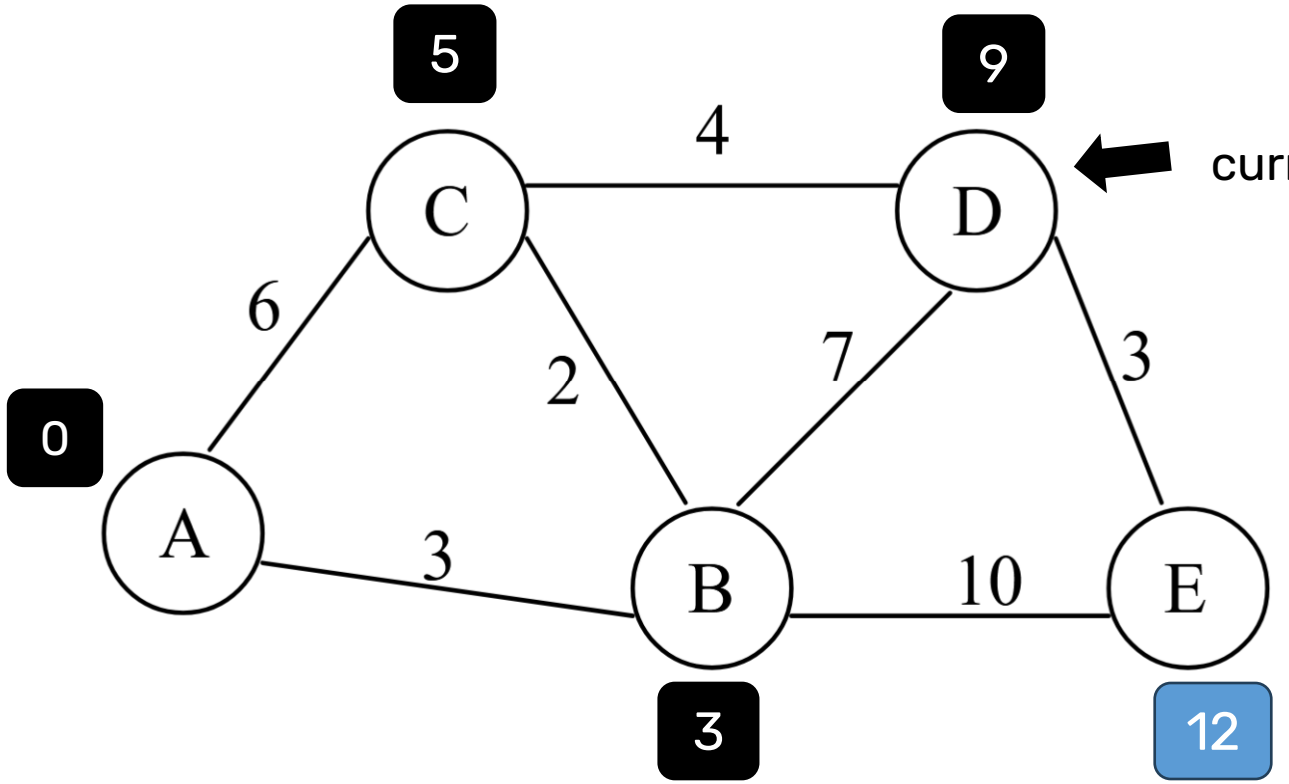


visited: {A, B, C}
not visited*: {D, E}

*sorted from smallest distance value to largest

distance

Q4

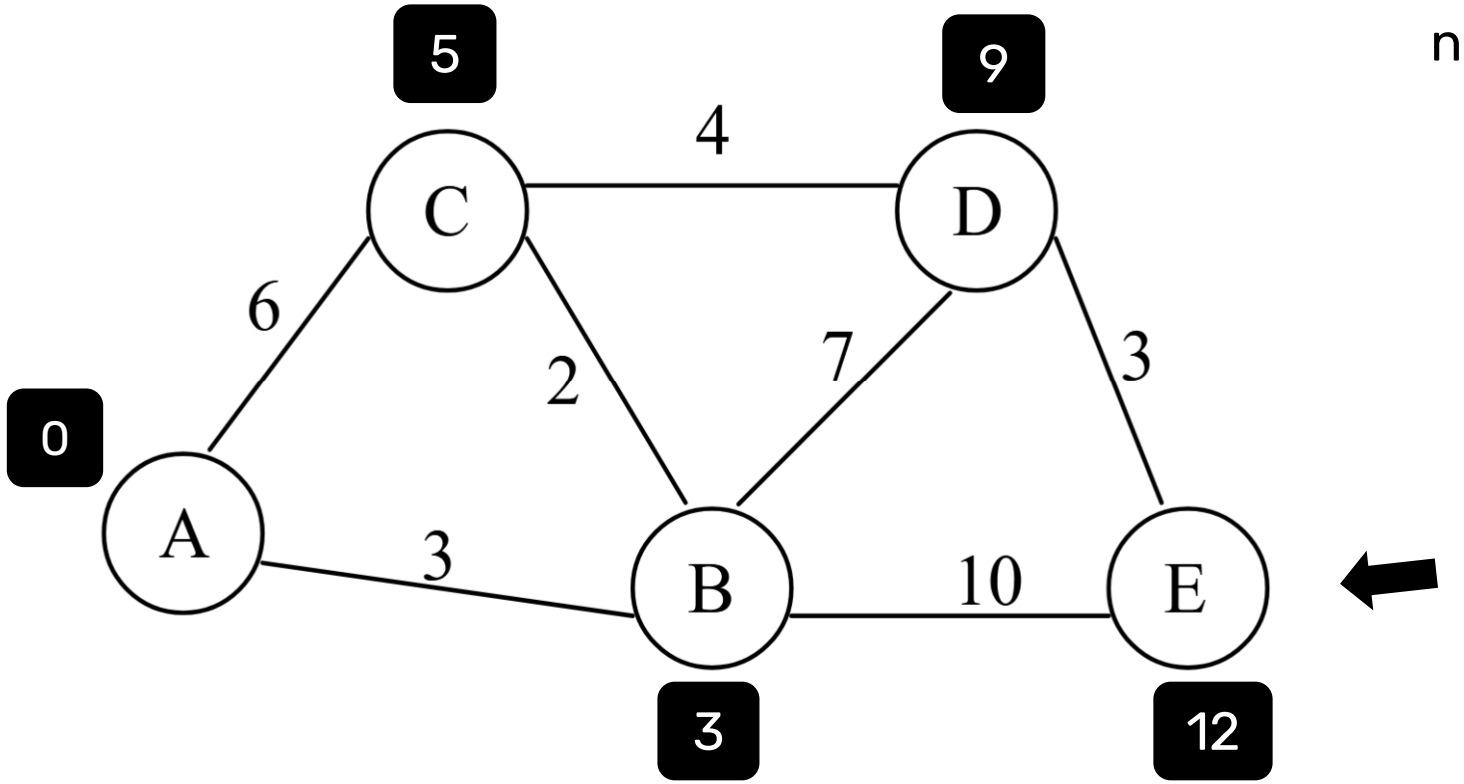


visited: {A, B, C, D}
not visited*: {E}

*sorted from smallest distance value to largest

distance

Q4



visited: {A, B, C, D, E}
not visited*: {}

current node

*sorted from smallest distance value to largest

Questions?

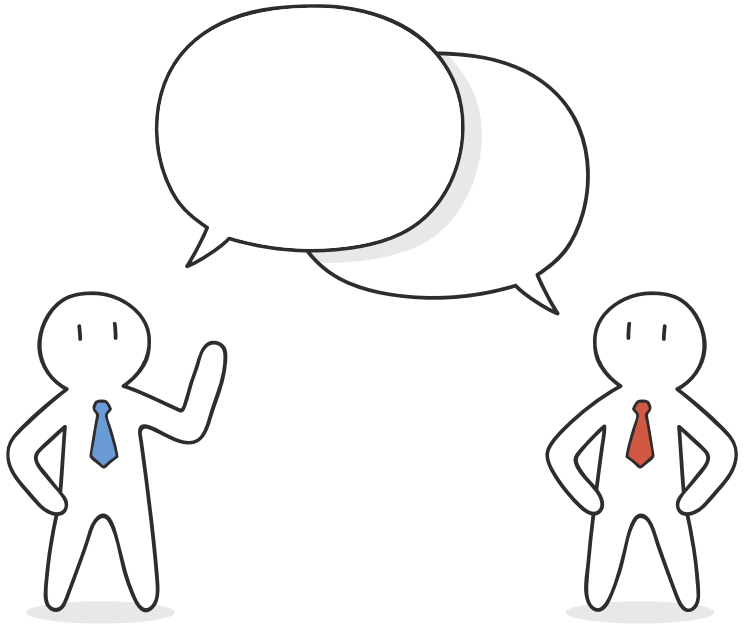


Image by dooder on Freepik