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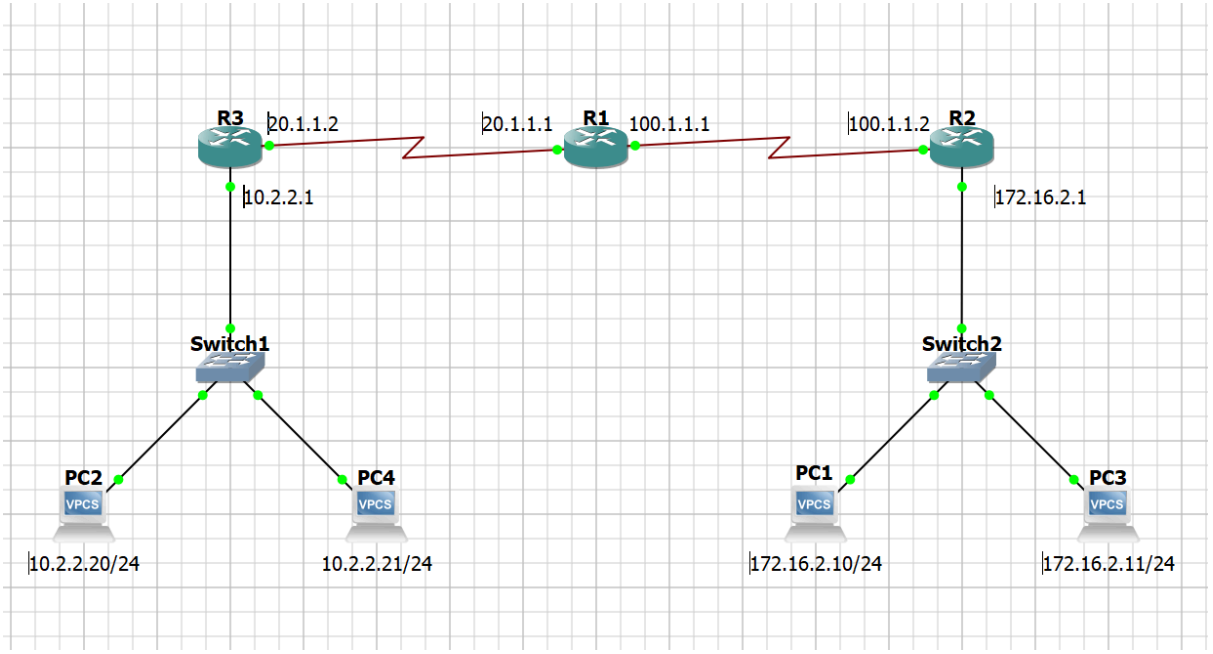
Q. Consider the following network consisting of three routers (R1, R2, R3), two switches (SW1, SW2), and four PCs.
The IP addressing details for all devices are given in the table below:

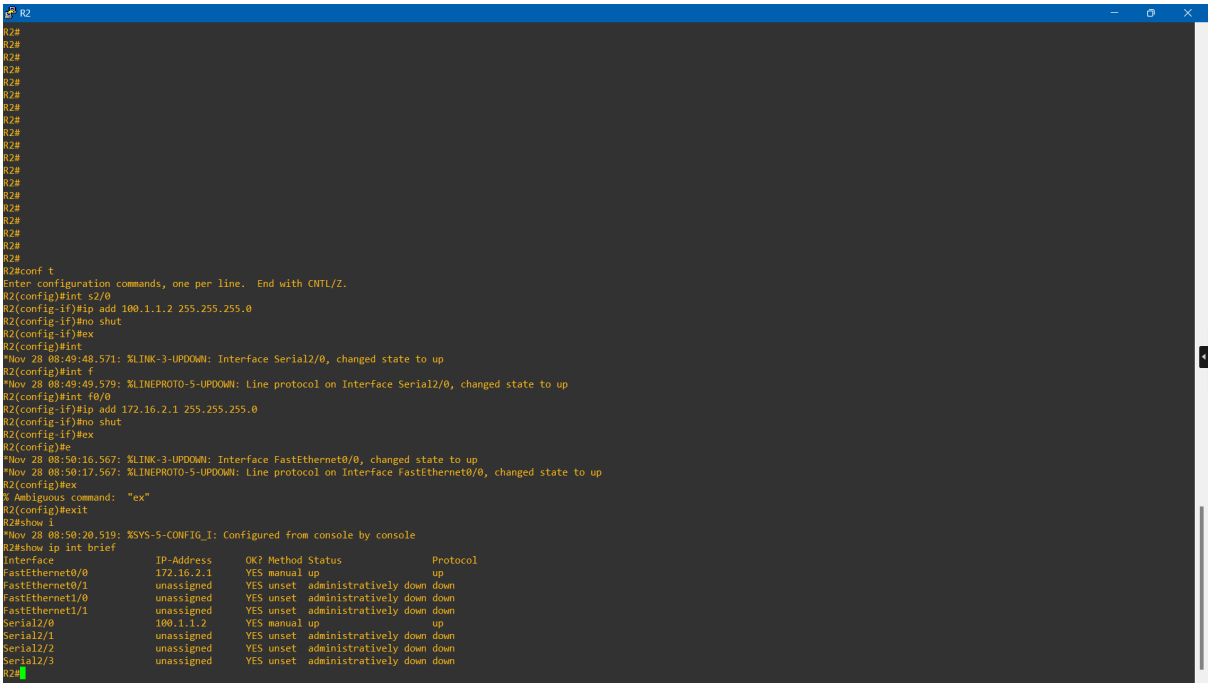
Device	Interface	IP Address	Subnet Mask
R1	s1/0	100.1.1.1	255.255.255.0
R1	s1/1	20.1.1.1	255.255.255.0
R2	s2/0	100.1.1.2	255.255.255.0
R2	f1/0	172.16.2.1	255.255.255.0
R3	s2/0	20.1.1.2	255.255.255.0
R3	f1/0	10.2.2.1	255.255.255.0
PC1	e0	172.16.2.10	255.255.255.0
PC3	e0	172.16.2.11	255.255.255.0
PC2	e0	10.2.2.20	255.255.255.0
PC4	e0	10.2.2.21	255.255.255.0

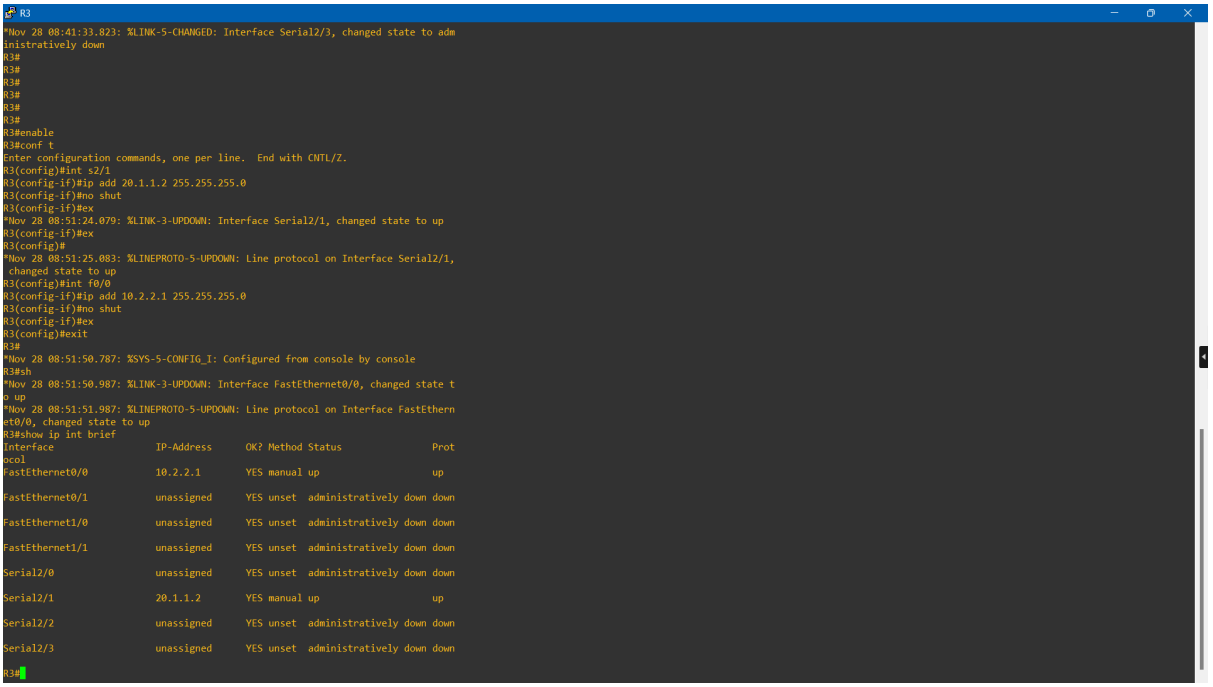
Using the above IP addressing scheme:

(a) Draw the complete network topology diagram showing all routers, switches, connections, and IP addresses.(3)




```
R1
R1#
*Nov 28 08:46:55.315: %SYS-5-CONFIG_I: Configured from console by console
R1#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
R1(config)#int s2/1
R1(config-if)#ip
*Nov 28 08:47:06.367: %LINEPROTO-5-UPDOWN: Line protocol on Interface Serial2/0,
 changed state to down
R1(config-if)#ip add 20.1.1.1 255.255.255.0
R1(config-if)#^Z
R1#
*Nov 28 08:47:21.935: %SYS-5-CONFIG_I: Configured from console by console
R1#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
R1(config)#int s2/1
R1(config-if)#ip add 20.1.1.1 255.255.255.0
R1(config-if)#no shut
R1(config-if)#ex
R1(config)#e
*Nov 28 08:47:35.687: %LINK-3-UPDOWN: Interface Serial2/1, changed state to up
R1(config)#ex
% Ambiguous command:  "ex"
R1(config)#
*Nov 28 08:47:36.695: %LINEPROTO-5-UPDOWN: Line protocol on Interface Serial2/1,
 changed state to up
R1(config)#^Z
R1#
R1#
R1#
*Nov 28 08:47:39.439: %SYS-5-CONFIG_I: Configured from console by console
R1#show ip int brief
Interface                  IP-Address      OK? Method Status                Prot
ocol
FastEthernet0/0            unassigned      YES unset  administratively down down

FastEthernet0/1            unassigned      YES unset  administratively down down

FastEthernet1/0            unassigned      YES unset  administratively down down

FastEthernet1/1            unassigned      YES unset  administratively down down

Serial2/0                  100.1.1.1       YES manual up                    down

Serial2/1                  20.1.1.1        YES manual up                    up

Serial2/2                  unassigned      YES unset  administratively down down

Serial2/3                  unassigned      YES unset  administratively down down

R1#
*Nov 28 08:48:06.379: %LINEPROTO-5-UPDOWN: Line protocol on Interface Serial2/1, changed state to down
R1#
```


R2
R2#
R2#
R2#
R2#
R2#
R2#
R2#
R2#
R2#
R2#
R2#
R2#
R2#
R2#
R2#
R2#
R2#
R2#
R2#conf t
Enter configuration commands, one per line. End with CNTL/Z.
R2(config)#int s2/0
R2(config-if)#ip add 100.1.1.2 255.255.255.0
R2(config-if)#no shut
R2(config-if)#ex
R2(config)#int
*Nov 28 08:49:48.571: %LINK-3-UPDOWN: Interface Serial2/0, changed state to up
R2(config)#int f
*Nov 28 08:49:49.579: %LINEPROTO-5-UPDOWN: Line protocol on Interface Serial2/0, changed state to up
R2(config)#int f0/0
R2(config-if)#ip add 172.16.2.1 255.255.255.0
R2(config-if)#no shut
R2(config-if)#ex
R2(config)#e
*Nov 28 08:50:16.567: %LINK-3-UPDOWN: Interface FastEthernet0/0, changed state to up
*Nov 28 08:50:17.567: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/0, changed state to up
R2(config)#ex
% Ambiguous command: "ex"
R2(config)#exit
R2#show i
*Nov 28 08:50:20.519: %SYS-5-CONFIG_I: Configured from console by console
R2#show ip int brief
Interface   IP-Address   OK? Method Status   Protocol
FastEthernet0/0   172.16.2.1   YES manual up   up
FastEthernet0/1   unassigned   YES unset administratively down down
FastEthernet1/0   unassigned   YES unset administratively down down
FastEthernet1/1   unassigned   YES unset administratively down down
Serial2/0   100.1.1.2   YES manual up   up
Serial2/1   unassigned   YES unset administratively down down
Serial2/2   unassigned   YES unset administratively down down
Serial2/3   unassigned   YES unset administratively down down
R2#


R3
*Nov 28 08:41:33.823: %LINK-5-CHANGED: Interface Serial2/3, changed state to adm
inistratively down
R3#
R3#
R3#
R3#
R3#
R3#
R3#enable
R3#conf t
Enter configuration commands, one per line. End with CNTL/Z.
R3(config)#int s2/1
R3(config-if)#ip add 20.1.1.2 255.255.255.0
R3(config-if)#no shut
R3(config-if)#ex
*Nov 28 08:51:24.079: %LINK-3-UPDOWN: Interface Serial2/1, changed state to up
R3(config-if)#ex
R3(config)#
*Nov 28 08:51:25.083: %LINEPROTO-5-UPDOWN: Line protocol on Interface Serial2/1,
 changed state to up
R3(config)#int f0/0
R3(config-if)#ip add 10.2.2.1 255.255.255.0
R3(config-if)#no shut
R3(config-if)#ex
R3(config)#exit
R3#
*Nov 28 08:51:50.787: %SYS-5-CONFIG_I: Configured from console by console
R3#sh
*Nov 28 08:51:50.987: %LINK-3-UPDOWN: Interface FastEthernet0/0, changed state t
o up
*Nov 28 08:51:51.987: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthern
et0/0, changed state to up
R3#show ip int brief
Interface   IP-Address   OK? Method Status   Prot
ocol
FastEthernet0/0   10.2.2.1   YES manual up   up

FastEthernet0/1   unassigned   YES unset administratively down down

FastEthernet1/0   unassigned   YES unset administratively down down

FastEthernet1/1   unassigned   YES unset administratively down down

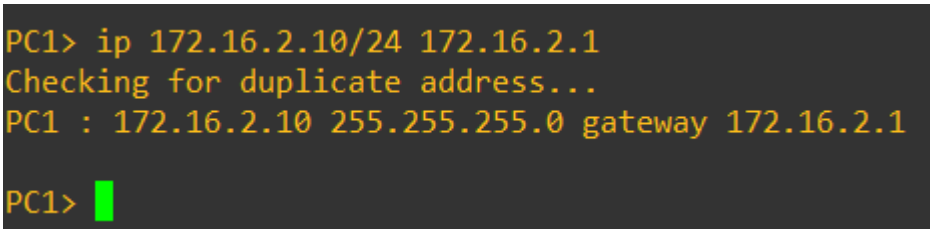
Serial2/0   unassigned   YES unset administratively down down

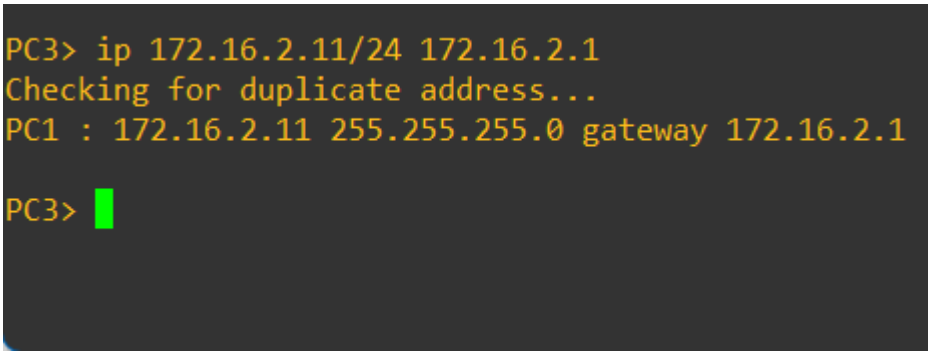
Serial2/1   20.1.1.2   YES manual up   up

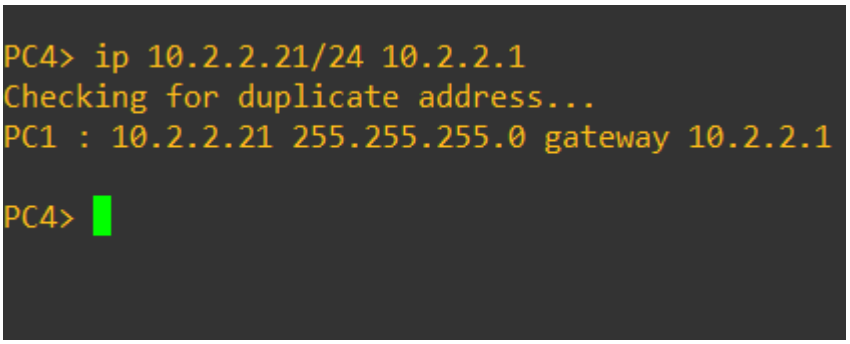
Serial2/2   unassigned   YES unset administratively down down

Serial2/3   unassigned   YES unset administratively down down

R3#


PC1> ip 172.16.2.10/24 172.16.2.1
Checking for duplicate address...
PC1 : 172.16.2.10 255.255.255.0 gateway 172.16.2.1
PC1>





(b) Configure all three routers using OSPF so that all four PCs can communicate with each other.(3)

```
R1(config)#router ospf
R1(config)#router ospf
R1(config)#router ospf 2
R1(config-router)#router ospf 1
R1(config-router)#ne
R1(config-router)#net
R1(config-router)#network add 100.1.1.0 20.1.1.0 area 0
                           ^
% Invalid input detected at '^' marker.

R1(config-router)#network 100.1.1.0 20.1.1.0 area 0
% OSPF: Invalid address/mask combination (discontiguous mask)
R1(config-router)#network 100.1.1.0 0.0.0.255
% Incomplete command.

R1(config-router)#network 100.1.1.0 0.0.0.25 area 0
% OSPF: Invalid address/mask combination (discontiguous mask)
R1(config-router)#network 100.1.1.0 0.0.0.25 area 0.0.0.0
% OSPF: Invalid address/mask combination (discontiguous mask)
R1(config-router)#network 100.1.1.0 0.0.0.255 area 0.0.0.0
R1(config-router)#network 20.1.1.0 0.0.0.255 area 0.0.0.0
R1(config-router)#
```

```
R2#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
R2(config)#router ospf 2
R2(config-router)#network 100.1.1.0 0.0.0.255 area 0
R2(config-router)#
*Nov 28 09:01:02.375: %OSPF-5-ADJCHG: Process 2, Nbr 20.1.1.1 on Serial2/0 from LOADING to FULL, Loading Done
R2(config-router)#network 172.16.2.0 0.0.0.255 area 0
R2(config-router)#no shut
R2(config-router)#ex
R2(config)#ex
% Ambiguous command:  "ex"
R2(config)#exit
R2#show
*Nov 28 09:01:31.667: %SYS-5-CONFIG_I: Configured from console by console
R2#show ip ospf ne
R2#show ip ospf neighbor

Neighbor ID     Pri   State           Dead Time   Address         Interface
20.1.1.1          0   FULL/  -        00:00:36    100.1.1.1       Serial2/0
R2#
```

```
R3#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
R3(config)#router ospf 3
R3(config-router)#netword 20.1.1.0 0.0.0.255 area 0
                     ^
% Invalid input detected at '^' marker.

R3(config-router)#network 20.1.1.0 0.0.0.255 area 0
R3(config-router)#network 20.1.1.0 0.0.0.255 area 0
*Nov 28 09:02:33.279: %OSPF-5-ADJCHG: Process 3, Nbr 20.1.1.1 on Serial2/1 from LOADING to FULL, Loading Done
R3(config-router)#network 10.2.2.0 0.0.0.255 area 0
R3(config-router)#show ip ospf ne
R3(config-router)#show ip ospf nei
R3(config-router)#show ip ospf neigh
R3(config-router)#show ip ospf neighbor
R3(config-router)#show ip ospf neighbor
                  ^
% Invalid input detected at '^' marker.

R3(config-router)#^Z
R3#show ip int brief
*Nov 28 09:02:58.579: %SYS-5-CONFIG_I: Configured from console by console
R3#show ip int brief
Interface                  IP-Address      OK? Method Status                Protocol
FastEthernet0/0            10.2.2.1        YES manual up                    up
FastEthernet0/1            unassigned      YES unset  administratively down down
FastEthernet1/0            unassigned      YES unset  administratively down down
FastEthernet1/1            unassigned      YES unset  administratively down down
Serial2/0                  unassigned      YES unset  administratively down down
Serial2/1                  20.1.1.2        YES manual up                    up
Serial2/2                  unassigned      YES unset  administratively down down
Serial2/3                  unassigned      YES unset  administratively down down
R3#
```

(c) Verify connectivity by writing the commands to: (4)

(i) Check routing tables on each router

```
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
       i - IS-IS, su - IS-IS summary, 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, H - NHRP, l - LISP
       + - replicated route, % - next hop override

Gateway of last resort is not set

      10.0.0.0/24 is subnetted, 1 subnets
O        10.2.2.0 [110/65] via 20.1.1.2, 00:04:08, Serial2/1
      20.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
C        20.1.1.0/24 is directly connected, Serial2/1
L        20.1.1.1/32 is directly connected, Serial2/1
      100.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
C        100.1.1.0/24 is directly connected, Serial2/0
L        100.1.1.1/32 is directly connected, Serial2/0
      172.16.0.0/24 is subnetted, 1 subnets
O        172.16.2.0 [110/65] via 100.1.1.2, 00:05:29, Serial2/0
R1#
```

```
R2#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
       i - IS-IS, su - IS-IS summary, 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, H - NHRP, l - LISP
       + - replicated route, % - next hop override

Gateway of last resort is not set

      10.0.0.0/24 is subnetted, 1 subnets
O        10.2.2.0 [110/129] via 100.1.1.1, 00:04:37, Serial2/0
      20.0.0.0/24 is subnetted, 1 subnets
O        20.1.1.0 [110/128] via 100.1.1.1, 00:06:18, Serial2/0
      100.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
C        100.1.1.0/24 is directly connected, Serial2/0
L        100.1.1.2/32 is directly connected, Serial2/0
      172.16.0.0/16 is variably subnetted, 2 subnets, 2 masks
C        172.16.2.0/24 is directly connected, FastEthernet0/0
L        172.16.2.1/32 is directly connected, FastEthernet0/0
R2#
```

```
R3#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
       i - IS-IS, su - IS-IS summary, 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, H - NHRP, l - LISP
       + - replicated route, % - next hop override

Gateway of last resort is not set

      10.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
C        10.2.2.0/24 is directly connected, FastEthernet0/0
L        10.2.2.1/32 is directly connected, FastEthernet0/0
      20.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
C        20.1.1.0/24 is directly connected, Serial2/1
L        20.1.1.2/32 is directly connected, Serial2/1
      100.0.0.0/24 is subnetted, 1 subnets
O        100.1.1.0 [110/128] via 20.1.1.1, 00:05:04, Serial2/1
      172.16.0.0/24 is subnetted, 1 subnets
O        172.16.2.0 [110/129] via 20.1.1.1, 00:05:04, Serial2/1
R3#
```

(ii) Ping PC2 from PC1

```
PC1> ping 10.2.2.20
84 bytes from 10.2.2.20 icmp_seq=1 ttl=61 time=122.116 ms
84 bytes from 10.2.2.20 icmp_seq=2 ttl=61 time=90.518 ms
84 bytes from 10.2.2.20 icmp_seq=3 ttl=61 time=91.391 ms
84 bytes from 10.2.2.20 icmp_seq=4 ttl=61 time=90.737 ms
84 bytes from 10.2.2.20 icmp_seq=5 ttl=61 time=91.586 ms

PC1>
```

(iii) Ping PC4 from PC3

```
PC3> ping 10.2.2.21
84 bytes from 10.2.2.21 icmp_seq=1 ttl=61 time=106.173 ms
84 bytes from 10.2.2.21 icmp_seq=2 ttl=61 time=91.424 ms
84 bytes from 10.2.2.21 icmp_seq=3 ttl=61 time=91.585 ms
84 bytes from 10.2.2.21 icmp_seq=4 ttl=61 time=91.805 ms
84 bytes from 10.2.2.21 icmp_seq=5 ttl=61 time=91.122 ms

PC3>
```