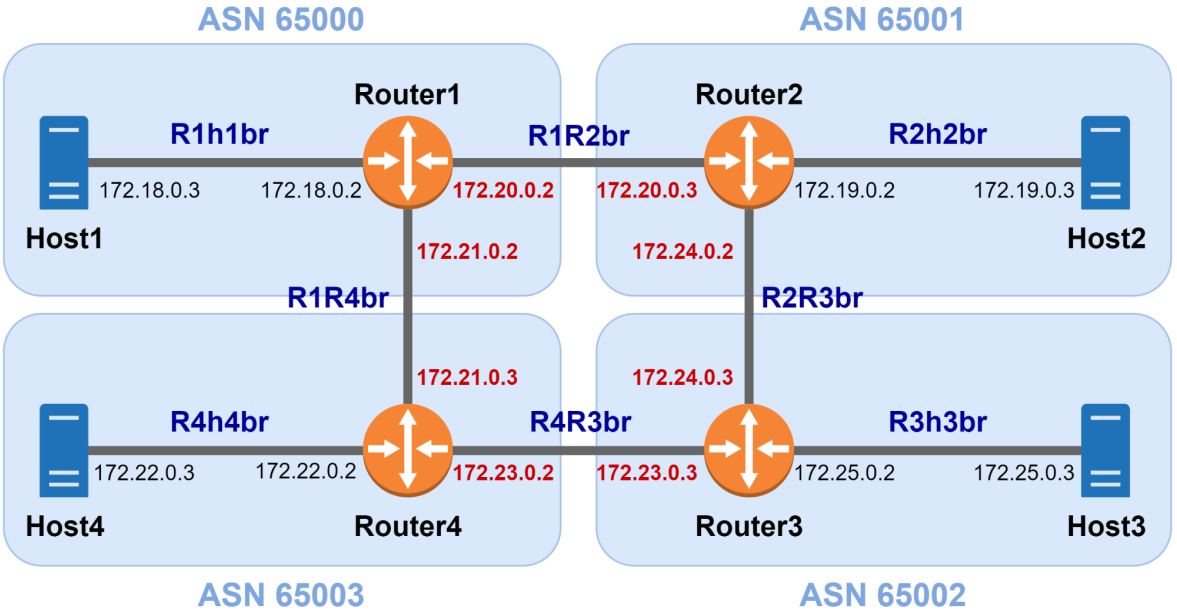
- **Show topology with IP addresses, interfaces and ASNs**



- **Capture one BGP packet from wireshark and show screenshots**

R1R2br

Source: R1 → Destination: R2

```
▸ Frame 27: 87 bytes on wire (696 bits), 87 bytes captured (696 bits) on interface 0
▾ Linux cooked capture
    Packet type: Unicast to another host (3)
    Link-layer address type: 1
    Link-layer address length: 6
    Source: 02:42:ac:14:00:02 (02:42:ac:14:00:02)
    Unused: 0000
    Protocol: IPv4 (0x0800)
▾ Internet Protocol Version 4, Src: 172.20.0.2, Dst: 172.20.0.3
    0100 .... = Version: 4
    .... 0101 = Header Length: 20 bytes (5)
  ▾ Differentiated Services Field: 0xc0 (DSCP: CS6, ECN: Not-ECT)
      1100 00.. = Differentiated Services Codepoint: Class Selector 6 (48)
      .... ..00 = Explicit Congestion Notification: Not ECN-Capable Transport (0)
    Total Length: 71
    Identification: 0x48fb (18683)
  ▸ Flags: 0x4000, Don't fragment
    Time to live: 255
    Protocol: TCP (6)
    Header checksum: 0xd9c7 [validation disabled]
    [Header checksum status: Unverified]
    Source: 172.20.0.2
    Destination: 172.20.0.3
▾ Transmission Control Protocol, Src Port: 179, Dst Port: 45672, Seq: 1, Ack: 20, Len: 19
    Source Port: 179
    Destination Port: 45672
    [Stream index: 3]
    [TCP Segment Len: 19]
    Sequence number: 1    (relative sequence number)
    [Next sequence number: 20    (relative sequence number)]
    Acknowledgment number: 20    (relative ack number)
    1000 .... = Header Length: 32 bytes (8)
  ▸ Flags: 0x018 (PSH, ACK)
    Window size value: 509
    [Calculated window size: 509]
    [Window size scaling factor: -1 (unknown)]
    Checksum: 0x5867 [unverified]
    [Checksum Status: Unverified]
    Urgent pointer: 0
  ▸ Options: (12 bytes), No-Operation (NOP), No-Operation (NOP), Timestamps
  ▸ [SEQ/ACK analysis]
  ▸ [Timestamps]
    TCP payload (19 bytes)
▾ Border Gateway Protocol - KEEPALIVE Message
    Marker: ffffffffffffffffffffffffffffffff
    Length: 19
    Type: KEEPALIVE Message (4)
```

Source: R2 → Destination: R1

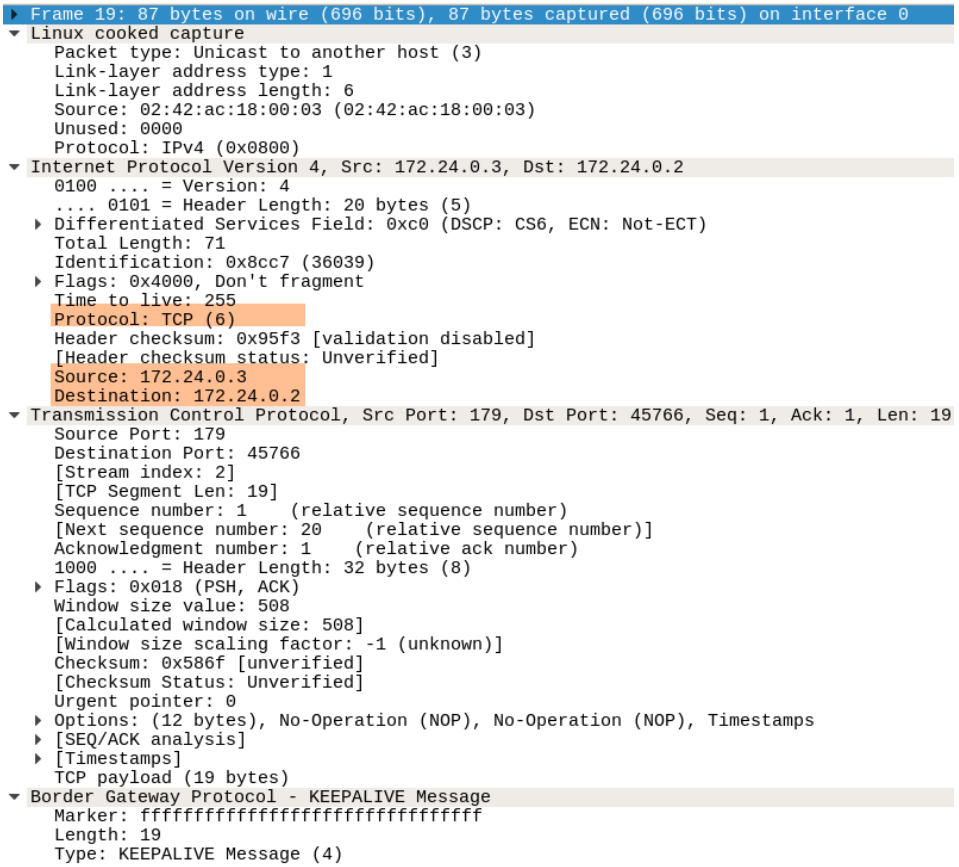
```
▸ Frame 25: 87 bytes on wire (696 bits), 87 bytes captured (696 bits) on interface 0
▾ Linux cooked capture
    Packet type: Unicast to another host (3)
    Link-layer address type: 1
    Link-layer address length: 6
    Source: 02:42:ac:14:00:03 (02:42:ac:14:00:03)
    Unused: 0000
    Protocol: IPv4 (0x0800)
▾ Internet Protocol Version 4, Src: 172.20.0.3, Dst: 172.20.0.2
    0100 .... = Version: 4
    .... 0101 = Header Length: 20 bytes (5)
  ▸ Differentiated Services Field: 0xc0 (DSCP: CS6, ECN: Not-ECT)
    Total Length: 71
    Identification: 0x2c81 (11393)
  ▸ Flags: 0x4000, Don't fragment
    Time to live: 255
    Protocol: TCP (6)
    Header checksum: 0xf641 [validation disabled]
    [Header checksum status: Unverified]
    Source: 172.20.0.3
    Destination: 172.20.0.2
▾ Transmission Control Protocol, Src Port: 45672, Dst Port: 179, Seq: 1, Ack: 1, Len: 19
    Source Port: 45672
    Destination Port: 179
    [Stream index: 3]
    [TCP Segment Len: 19]
    Sequence number: 1    (relative sequence number)
    [Next sequence number: 20    (relative sequence number)]
    Acknowledgment number: 1    (relative ack number)
    1000 .... = Header Length: 32 bytes (8)
  ▸ Flags: 0x018 (PSH, ACK)
    Window size value: 502
    [Calculated window size: 502]
    [Window size scaling factor: -1 (unknown)]
    Checksum: 0x5867 [unverified]
    [Checksum Status: Unverified]
    Urgent pointer: 0
  ▸ Options: (12 bytes), No-Operation (NOP), No-Operation (NOP), Timestamps
  ▸ [SEQ/ACK analysis]
  ▸ [Timestamps]
    TCP payload (19 bytes)
▾ Border Gateway Protocol - KEEPALIVE Message
    Marker: ffffffffffffffffffffffffffffffff
    Length: 19
    Type: KEEPALIVE Message (4)
```

R2R3br

Source: R2 → Destination: R3

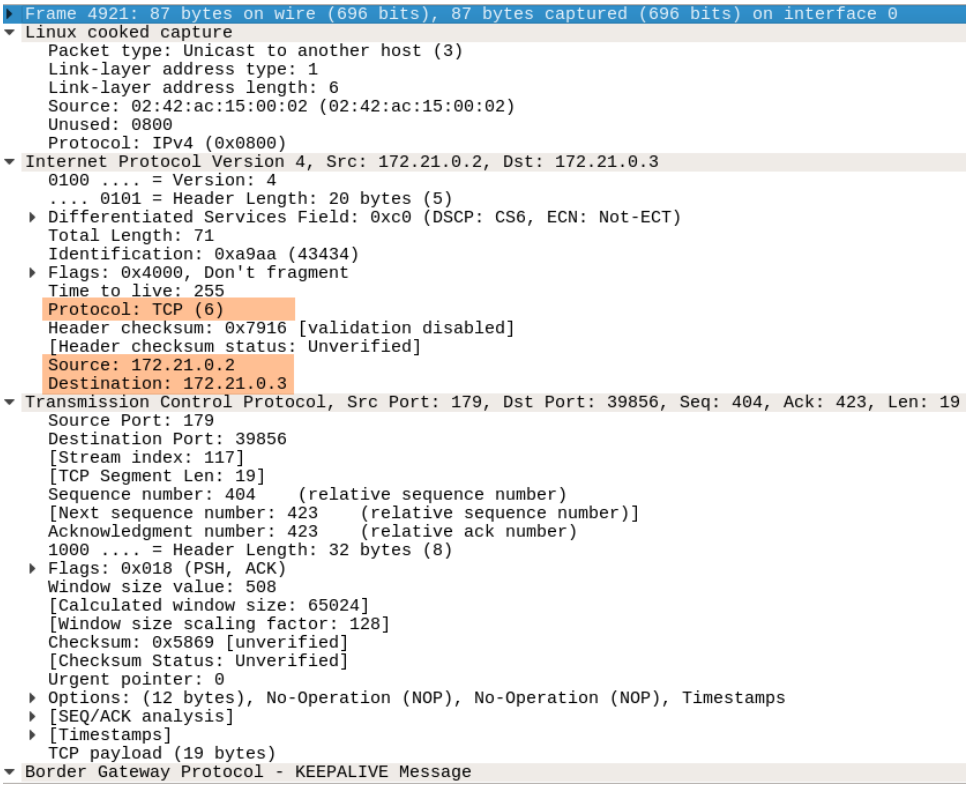
```
▸ Frame 21: 87 bytes on wire (696 bits), 87 bytes captured (696 bits) on interface 0
▾ Linux cooked capture
    Packet type: Unicast to another host (3)
    Link-layer address type: 1
    Link-layer address length: 6
    Source: 02:42:ac:18:00:02 (02:42:ac:18:00:02)
    Unused: 0000
    Protocol: IPv4 (0x0800)
▾ Internet Protocol Version 4, Src: 172.24.0.2, Dst: 172.24.0.3
    0100 .... = Version: 4
    .... 0101 = Header Length: 20 bytes (5)
  ▸ Differentiated Services Field: 0xc0 (DSCP: CS6, ECN: Not-ECT)
    Total Length: 71
    Identification: 0x548f (21647)
  ▸ Flags: 0x4000, Don't fragment
    Time to live: 255
    Protocol: TCP (6)
    Header checksum: 0xce2b [validation disabled]
    [Header checksum status: Unverified]
    Source: 172.24.0.2
    Destination: 172.24.0.3
▾ Transmission Control Protocol, Src Port: 45766, Dst Port: 179, Seq: 1, Ack: 20, Len: 19
    Source Port: 45766
    Destination Port: 179
    [Stream index: 2]
    [TCP Segment Len: 19]
    Sequence number: 1    (relative sequence number)
    [Next sequence number: 20    (relative sequence number)]
    Acknowledgment number: 20    (relative ack number)
    1000 .... = Header Length: 32 bytes (8)
  ▸ Flags: 0x018 (PSH, ACK)
    Window size value: 501
    [Calculated window size: 501]
    [Window size scaling factor: -1 (unknown)]
    Checksum: 0x586f [unverified]
    [Checksum Status: Unverified]
    Urgent pointer: 0
  ▸ Options: (12 bytes), No-Operation (NOP), No-Operation (NOP), Timestamps
  ▸ [SEQ/ACK analysis]
  ▸ [Timestamps]
    TCP payload (19 bytes)
▾ Border Gateway Protocol - KEEPALIVE Message
    Marker: ffffffffffffffffffffffffffffffff
    Length: 19
    Type: KEEPALIVE Message (4)
```

Source: R3 → Destination: R2



R1R4br

Source: R1 → Destination: R4



Source: R4 → Destination: R1

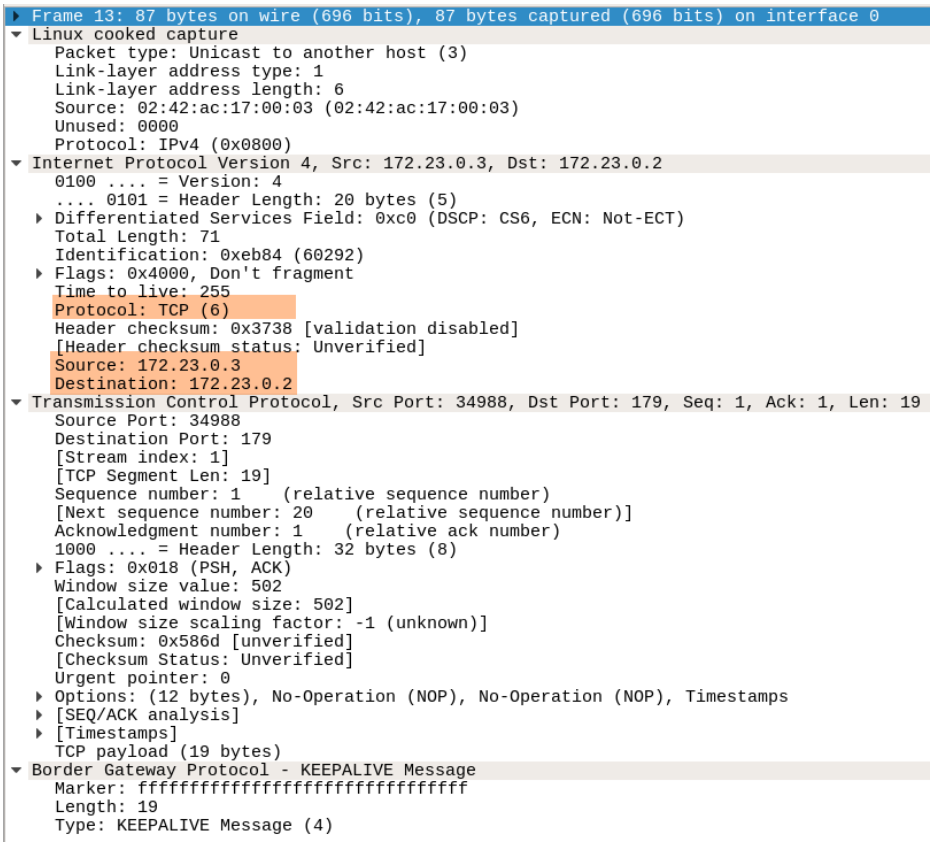
```
▸ Frame 4919: 87 bytes on wire (696 bits), 87 bytes captured (696 bits) on interface 0
▾ Linux cooked capture
    Packet type: Unicast to another host (3)
    Link-layer address type: 1
    Link-layer address length: 6
    Source: 02:42:ac:15:00:03 (02:42:ac:15:00:03)
    Unused: e7a5
    Protocol: IPv4 (0x0800)
▾ Internet Protocol Version 4, Src: 172.21.0.3, Dst: 172.21.0.2
    0100 .... = Version: 4
    .... 0101 = Header Length: 20 bytes (5)
  ▸ Differentiated Services Field: 0xc0 (DSCP: CS6, ECN: Not-ECT)
    Total Length: 71
    Identification: 0x3061 (12385)
  ▸ Flags: 0x4000, Don't fragment
    Time to live: 255
    Protocol: TCP (6)
    Header checksum: 0xf25f [validation disabled]
    [Header checksum status: Unverified]
    Source: 172.21.0.3
    Destination: 172.21.0.2
▾ Transmission Control Protocol, Src Port: 39856, Dst Port: 179, Seq: 404, Ack: 404, Len: 19
    Source Port: 39856
    Destination Port: 179
    [Stream index: 117]
    [TCP Segment Len: 19]
    Sequence number: 404    (relative sequence number)
    [Next sequence number: 423    (relative sequence number)]
    Acknowledgment number: 404    (relative ack number)
    1000 .... = Header Length: 32 bytes (8)
  ▸ Flags: 0x018 (PSH, ACK)
    Window size value: 501
    [Calculated window size: 64128]
    [Window size scaling factor: 128]
    Checksum: 0x5869 [unverified]
    [Checksum Status: Unverified]
    Urgent pointer: 0
  ▸ Options: (12 bytes), No-Operation (NOP), No-Operation (NOP), Timestamps
  ▸ [SEQ/ACK analysis]
  ▸ [Timestamps]
    TCP payload (19 bytes)
▾ Border Gateway Protocol - KEEPALIVE Message
```

R4R3br

Source: R4 → Destination: R3

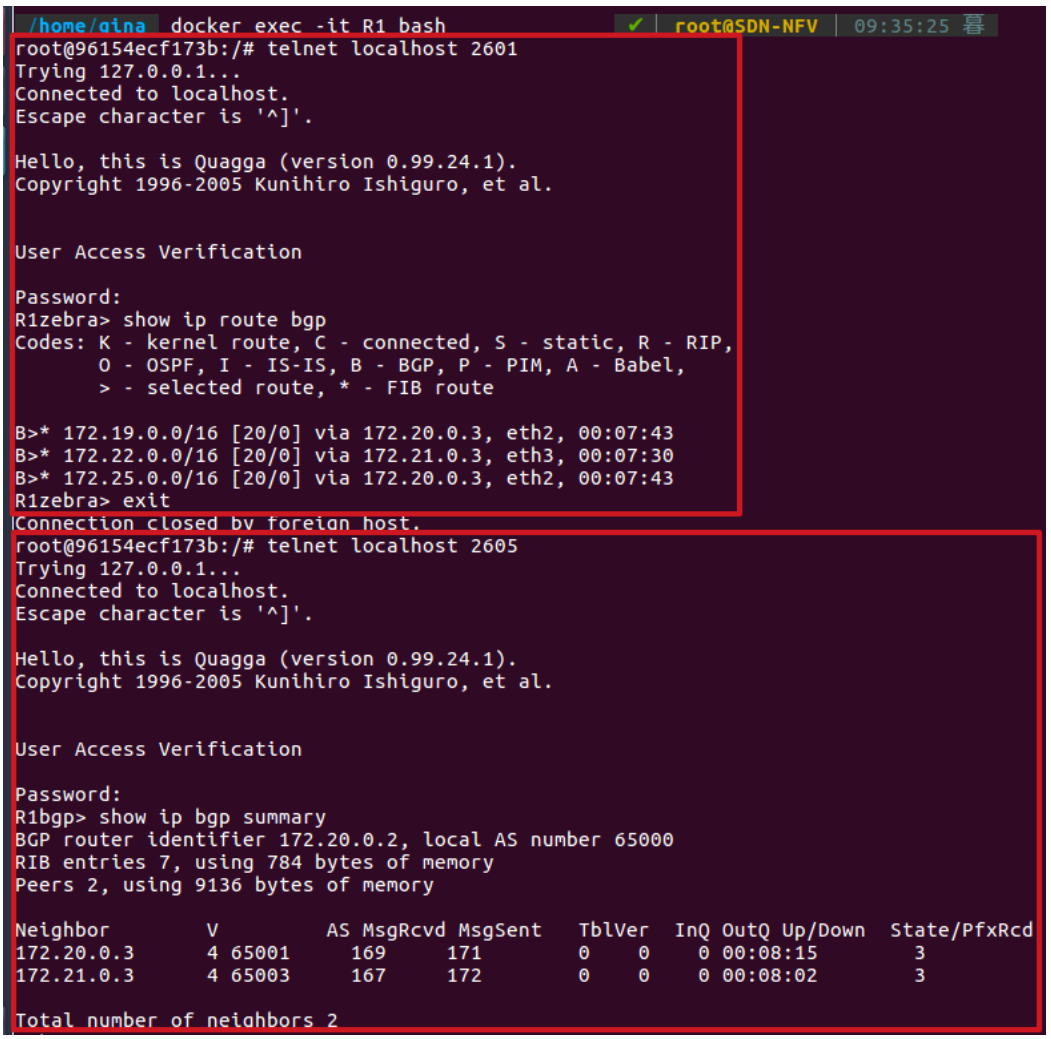
```
▸ Frame 15: 87 bytes on wire (696 bits), 87 bytes captured (696 bits) on interface 0
▾ Linux cooked capture
    Packet type: Unicast to another host (3)
    Link-layer address type: 1
    Link-layer address length: 6
    Source: 02:42:ac:17:00:02 (02:42:ac:17:00:02)
    Unused: 0000
    Protocol: IPv4 (0x0800)
▾ Internet Protocol Version 4, Src: 172.23.0.2, Dst: 172.23.0.3
    0100 .... = Version: 4
    .... 0101 = Header Length: 20 bytes (5)
  ▸ Differentiated Services Field: 0xc0 (DSCP: CS6, ECN: Not-ECT)
    Total Length: 71
    Identification: 0x477e (18302)
  ▸ Flags: 0x4000, Don't fragment
    Time to live: 255
    Protocol: TCP (6)
    Header checksum: 0xdb3e [validation disabled]
    [Header checksum status: Unverified]
    Source: 172.23.0.2
    Destination: 172.23.0.3
▾ Transmission Control Protocol, Src Port: 179, Dst Port: 34988, Seq: 1, Ack: 20, Len: 19
    Source Port: 179
    Destination Port: 34988
    [Stream index: 1]
    [TCP Segment Len: 19]
    Sequence number: 1    (relative sequence number)
    [Next sequence number: 20    (relative sequence number)]
    Acknowledgment number: 20    (relative ack number)
    1000 .... = Header Length: 32 bytes (8)
  ▸ Flags: 0x018 (PSH, ACK)
    Window size value: 509
    [Calculated window size: 509]
    [Window size scaling factor: -1 (unknown)]
    Checksum: 0x586d [unverified]
    [Checksum Status: Unverified]
    Urgent pointer: 0
  ▸ Options: (12 bytes), No-Operation (NOP), No-Operation (NOP), Timestamps
  ▸ [SEQ/ACK analysis]
  ▸ [Timestamps]
    TCP payload (19 bytes)
▾ Border Gateway Protocol - KEEPALIVE Message
    Marker: ffffffffffffffffffffffffffffffff
    Length: 19
    Type: KEEPALIVE Message (4)
```

Source: R3 → Destination: R4

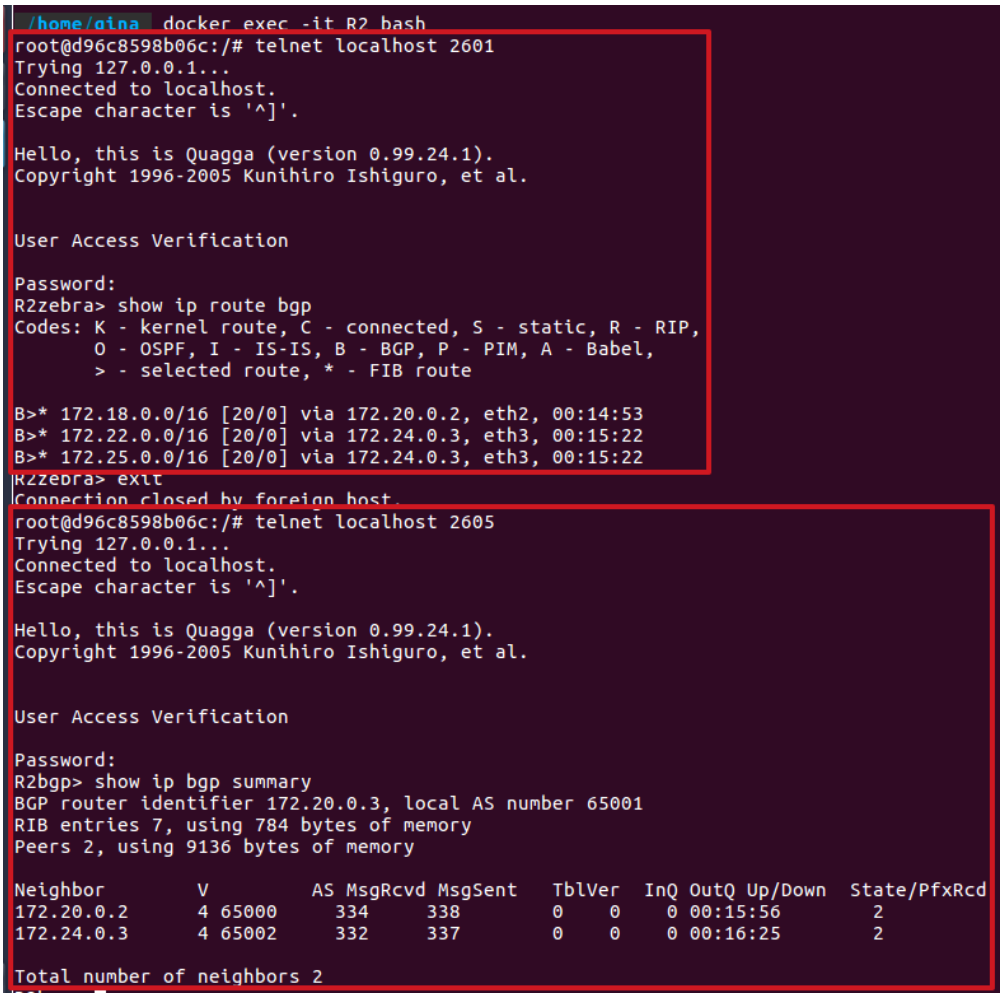


- **Telnet zebra and bgpd daemons of each route and show route screenshots**

  Router1



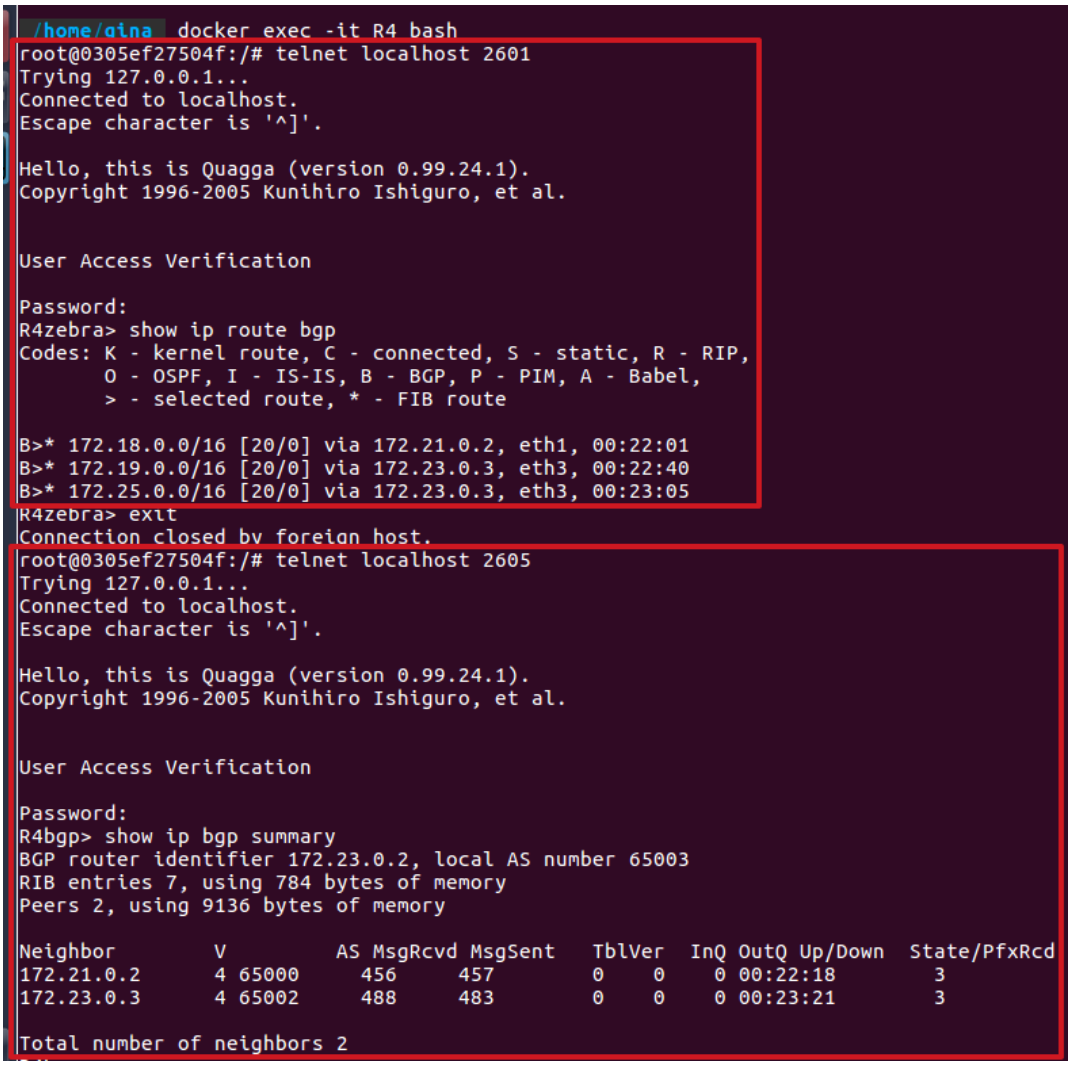
Router2


/home/gina docker exec -it R2 bash
root@d96c8598b06c:/# telnet localhost 2601
Trying 127.0.0.1...
Connected to localhost.
Escape character is '^]'.
Hello, this is Quagga (version 0.99.24.1).
Copyright 1996-2005 Kunihiro Ishiguro, et al.
User Access Verification
Password:
R2zebra> show ip route bgp
Codes: K - kernel route, C - connected, S - static, R - RIP,
O - OSPF, I - IS-IS, B - BGP, P - PIM, A - Babel,
> - selected route, * - FIB route
B>* 172.18.0.0/16 [20/0] via 172.20.0.2, eth2, 00:14:53
B>* 172.22.0.0/16 [20/0] via 172.24.0.3, eth3, 00:15:22
B>* 172.25.0.0/16 [20/0] via 172.24.0.3, eth3, 00:15:22
R2zebra> exit
Connection closed by foreign host.
root@d96c8598b06c:/# telnet localhost 2605
Trying 127.0.0.1...
Connected to localhost.
Escape character is '^]'.
Hello, this is Quagga (version 0.99.24.1).
Copyright 1996-2005 Kunihiro Ishiguro, et al.
User Access Verification
Password:
R2bgp> show ip bgp summary
BGP router identifier 172.20.0.3, local AS number 65001
RIB entries 7, using 784 bytes of memory
Peers 2, using 9136 bytes of memory
Neighbor V AS MsgRcvd MsgSent TblVer InQ OutQ Up/Down State/PfxRcd
172.20.0.2 4 65000 334 338 0 0 0 00:15:56 2
172.24.0.3 4 65002 332 337 0 0 0 00:16:25 2
Total number of neighbors 2

Router3

```
/home/qina  docker exec -it R3 bash
root@22e650c6fbe2:/# telnet localhost 2601
Trying 127.0.0.1...
Connected to localhost.
Escape character is '^]'.

Hello, this is Quagga (version 0.99.24.1).
Copyright 1996-2005 Kunihiro Ishiguro, et al.


User Access Verification

Password:
R3zebra> show ip route bgp
Codes: K - kernel route, C - connected, S - static, R - RIP,
       O - OSPF, I - IS-IS, B - BGP, P - PIM, A - Babel,
       > - selected route, * - FIB route

B>* 172.18.0.0/16 [20/0] via 172.24.0.2, eth2, 00:19:29
B>* 172.19.0.0/16 [20/0] via 172.24.0.2, eth2, 00:19:59
B>* 172.22.0.0/16 [20/0] via 172.23.0.2, eth1, 00:20:21
R3zebra> exit
Connection closed by foreign host.
root@22e650c6fbe2:/# telnet localhost 2605
Trying 127.0.0.1...
Connected to localhost.
Escape character is '^]'.

Hello, this is Quagga (version 0.99.24.1).
Copyright 1996-2005 Kunihiro Ishiguro, et al.


User Access Verification

Password:
R3bgp> show ip bgp summary
BGP router identifier 172.23.0.3, local AS number 65002
RIB entries 7, using 784 bytes of memory
Peers 2, using 9136 bytes of memory

Neighbor        V         AS MsgRcvd MsgSent   TblVer  InQ OutQ Up/Down  State/PfxRcd
172.23.0.2      4 65003     424     433        0    0    0 00:21:01        2
172.24.0.2      4 65001     431     430        0    0    0 00:20:40        2

Total number of neighbors 2
```

Router4



- **Write down what you have learned or solved**

I learned how to look up and modify the host's default gateway. And how to turn on the host ip forwarding function to serve the bridge mode like a router role. I also learned how to install and configure quagga service config like zebra and bgpd to let the network communicate with each other.
At the beginning, I tried to add another router ASN setting on the same router. For example, router1 connects to router2 and router4, so I think router1 needs to be declared two router ASN, and each ASN defines how to connect one of the routers. After I tried to use the configuration that I mentioned, and restart the quagga service, it failed because quagga service couldn't restart successfully. Then, I tried to append another neighborhood setting as router ASN, it worked like a charm.
Thanks to the TA and professor for teaching us about networking knowledge, that is the most important ability I need to improve for my job.