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Sprawozdanie z realizacji laboratorium KRI nr 4
BGP

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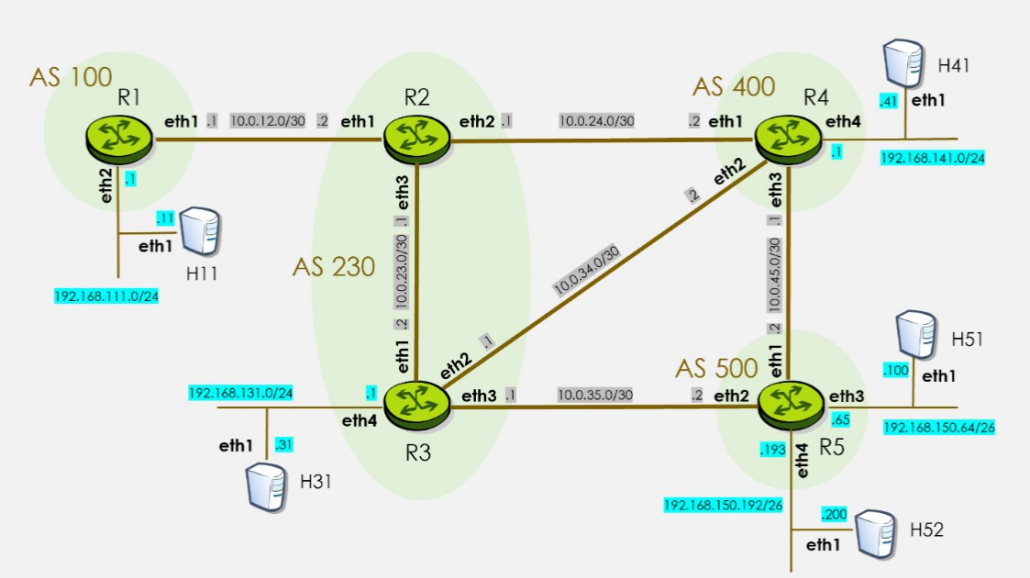
Spis treści

Wstęp

Niniejszy dokument to sprawozdanie z realizacji laboratorium w ramach przedmiotu KRI. Oświadczamy, że ta praca, stanowiąca podstawę do uznania osiągnięcia efektów uczenia się z przedmiotu KRI, została wykonana przez nas samodzielnie.

1. Zadanie A: Przypisanie adresów IP

W ramach tego laboratorium otrzymaliśmy skonfigurowaną sieć, której topologia i adresacja są przedstawione poniżej.



Rys. 1: Topologia wykorzystywanej sieci

Router	AS	Interface	Address
R1	AS100	lo	1.1.1.1/32
R4	AS400	lo	4.4.4.4/32
R5	AS500	lo	5.5.5.5/32
R2	AS230	lo	2.2.2.2/32
R3	AS230	lo	3.3.3.3/32

Rys. 2: Adresacja numerów AS i adresów loopback

2. Zadanie B: Konfiguracja OSPF w AS 230

Zgodnie z poleceniem skonfigurowaliśmy routing wewnątrz AS 230 przy pomocy protokołu OSPF. Poniżej można zobaczyć potwierdzanie tego, że konfiguracja została wykonana poprawnie. Świadczą o tym za równo zdjęcie z rezultatów komend ping oraz zdjęcia tablic routingu dla **R2** i **R3**

```
R2# ping 3.3.3.3
PING 3.3.3.3 (3.3.3.3): 56 data bytes
64 bytes from 3.3.3.3: seq=0 ttl=64 time=0.072 ms
64 bytes from 3.3.3.3: seq=1 ttl=64 time=0.070 ms
^C
--- 3.3.3.3 ping statistics ---
2 packets transmitted, 2 packets received, 0% packet loss
round-trip min/avg/max = 0.070/0.071/0.072 ms
```

Rys. 3: Wynik wykonania *ping* na **R2**

```
R3# ping 2.2.2.2
PING 2.2.2.2 (2.2.2.2): 56 data bytes
64 bytes from 2.2.2.2: seq=0 ttl=64 time=0.128 ms
64 bytes from 2.2.2.2: seq=1 ttl=64 time=0.096 ms
^C
--- 2.2.2.2 ping statistics ---
2 packets transmitted, 2 packets received, 0% packet loss
round-trip min/avg/max = 0.096/0.112/0.128 ms
```

Rys. 4: Wynik wykonania *ping* na **R3**

```
R2# show ip route
Codes: K - kernel route, C - connected, S - static, R - RIP,
       O - OSPF, I - IS-IS, B - BGP, E - EIGRP, N - NHRP,
       T - Table, v - VNC, V - VNC-Direct, A - Babel, F - PBR,
       f - OpenFabric,
       > - selected route, * - FIB route, q - queued, r - rejected, b - backup
       t - trapped, o - offload failure

K>* 0.0.0.0/0 [0/0] via 172.20.20.1, eth0, 01:03:14
O   2.2.2.2/32 [110/0] is directly connected, lo, weight 1, 00:35:24
C>* 2.2.2.2/32 is directly connected, lo, 01:03:12
O>* 3.3.3.3/32 [110/10] via 10.0.23.2, eth3, weight 1, 00:35:22
C>* 10.0.12.0/30 is directly connected, eth1, 01:03:07
O   10.0.23.0/30 [110/10] is directly connected, eth3, weight 1, 00:35:42
C>* 10.0.23.0/30 is directly connected, eth3, 01:03:10
C>* 10.0.24.0/30 is directly connected, eth2, 01:03:08
C>* 172.20.20.0/24 is directly connected, eth0, 01:03:14
R2#
```

Rys. 5: Tablica routingu na **R2**

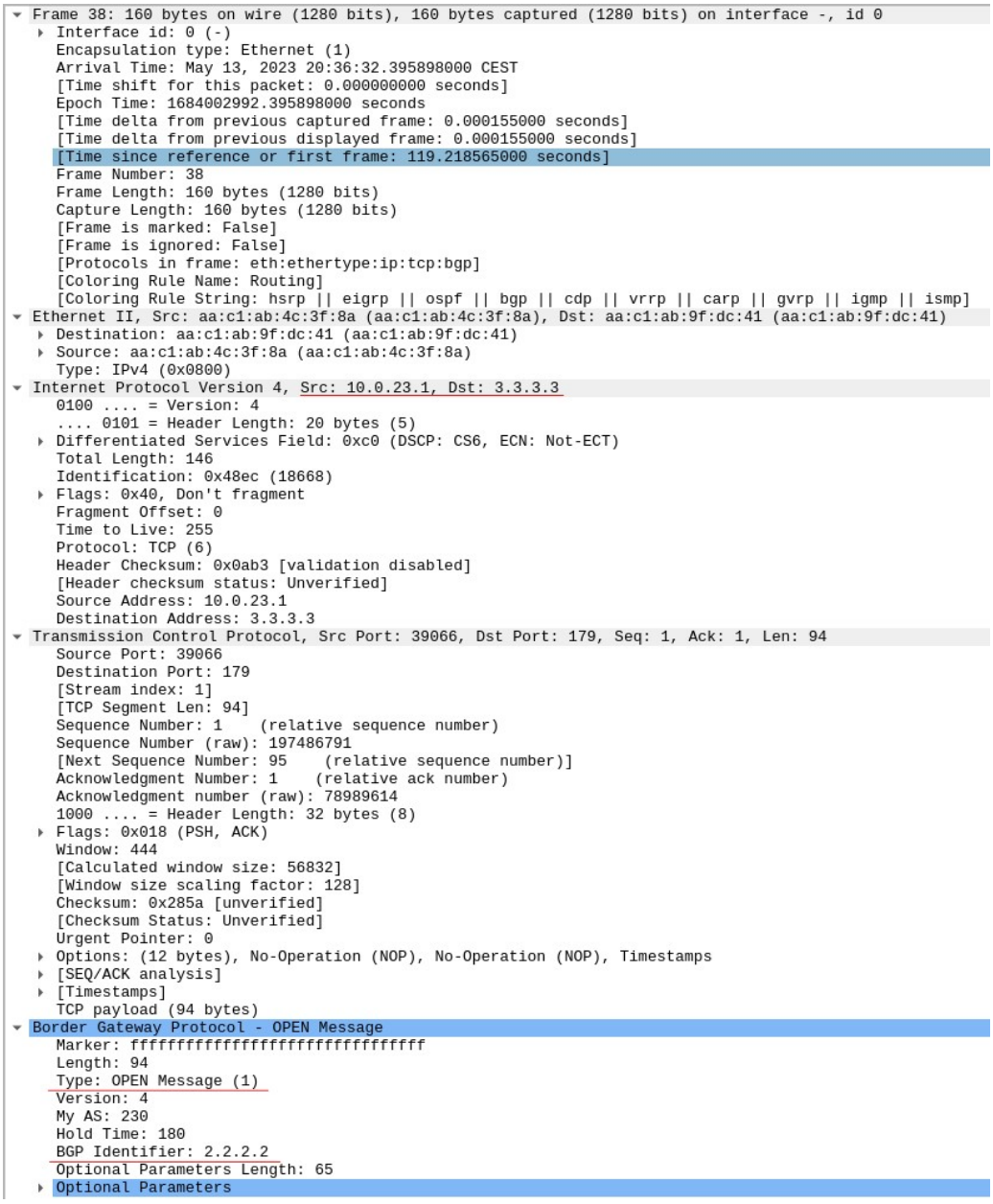
```
R3# show ip route
Codes: K - kernel route, C - connected, S - static, R - RIP,
       O - OSPF, I - IS-IS, B - BGP, E - EIGRP, N - NHRP,
       T - Table, v - VNC, V - VNC-Direct, A - Babel, F - PBR,
       f - OpenFabric,
       > - selected route, * - FIB route, q - queued, r - rejected, b - backup
       t - trapped, o - offload failure

K>* 0.0.0.0/0 [0/0] via 172.20.20.1, eth0, 01:02:59
O>* 2.2.2.2/32 [110/10] via 10.0.23.1, eth1, weight 1, 00:35:14
O   3.3.3.3/32 [110/0] is directly connected, lo, weight 1, 00:38:36
C>* 3.3.3.3/32 is directly connected, lo, 01:02:58
O   10.0.23.0/30 [110/10] is directly connected, eth1, weight 1, 00:39:22
C>* 10.0.23.0/30 is directly connected, eth1, 01:02:58
C>* 10.0.34.0/30 is directly connected, eth2, 01:02:58
C>* 10.0.35.0/30 is directly connected, eth3, 01:02:58
C>* 172.20.20.0/24 is directly connected, eth0, 01:02:59
C>* 192.168.131.0/24 is directly connected, eth4, 01:02:58
R3#
```

Rys. 6: Tablica routingu na **R3**

3. Zadanie C: Podstawowa konfiguracja BGP

3.1. Zadanie C1

Zgodnie z poleceniem konfigurowaliśmy routing iBGP między **R2** i **R3** jednocześnie obserwując ruch powstały w wyniku naszej konfiguracji. Poniżej można zobaczyć zawartość wiadomości **OPEN**, która została wysłana w trakcie nawiązywania sesji BGP



Rys. 7: Wiadomość OPEN

Celem wiadomości **OPEN** jest zainicjowanie komunikacji między dwoma routerami, negocjowanie parametrów sesji BGP i sprawdzenie, czy oba routery są ze sobą kompatybilne. Gdy oba routery wymienią otwarte wiadomości i uzgodnią parametry sesji BGP, mogą rozpocząć wymianę aktualizacji informacji o routingu w swoich sieciach.

Później dokonaliśmy zmiany source na interface **lo** (loopback) co spowodowało dodatkowy ruch na łączu mający na celu zaktualizowanie stanu sieci.

bgp

No.	Time	Source	Destination	Protocol	Length	Info
15	46.741757	10.0.23.2	2.2.2.2	BGP	160	OPEN Message
38	119.218565	10.0.23.1	3.3.3.3	BGP	160	OPEN Message
58	166.744321	10.0.23.2	2.2.2.2	BGP	160	OPEN Message
64	169.448090	3.3.3.3	2.2.2.2	BGP	160	OPEN Message
66	169.449217	2.2.2.2	3.3.3.3	BGP	160	OPEN Message
68	169.449498	2.2.2.2	3.3.3.3	BGP	85	KEEPALIVE Message
70	169.450050	3.3.3.3	2.2.2.2	BGP	85	KEEPALIVE Message
74	170.503783	3.3.3.3	2.2.2.2	BGP	89	UPDATE Message
76	170.551611	2.2.2.2	3.3.3.3	BGP	89	UPDATE Message
78	178.758926	2.2.2.2	3.3.3.3	BGP	87	NOTIFICATION Message
88	180.761809	2.2.2.2	3.3.3.3	BGP	160	OPEN Message
93	180.762794	2.2.2.2	3.3.3.3	BGP	160	OPEN Message
95	180.763338	3.3.3.3	2.2.2.2	BGP	160	OPEN Message
97	180.763412	3.3.3.3	2.2.2.2	BGP	160	OPEN Message
99	180.763464	3.3.3.3	2.2.2.2	BGP	87	NOTIFICATION Message
101	180.763660	2.2.2.2	3.3.3.3	BGP	87	NOTIFICATION Message
103	180.770257	2.2.2.2	3.3.3.3	BGP	85	KEEPALIVE Message
106	180.780166	3.3.3.3	2.2.2.2	BGP	85	KEEPALIVE Message
108	181.881716	3.3.3.3	2.2.2.2	BGP	89	UPDATE Message
110	181.882710	2.2.2.2	3.3.3.3	BGP	89	UPDATE Message

Rys. 8: Ruch wywołany konfiguracją protokołu BGP pomiędzy **R2** i **R3**

```
R2# show ip bgp summary

IPv4 Unicast Summary (VRF default):
BGP router identifier 2.2.2.2, local AS number 230 vrf-id 0
BGP table version 0
RIB entries 0, using 0 bytes of memory
Peers 1, using 718 KiB of memory

Neighbor        V         AS   MsgRcvd   MsgSent   TblVer  InQ OutQ  Up/Down State/PfxRcd   PfxSnt Desc
3.3.3.3         4        230         7        10        0    0    0 00:00:39            0        0 N/A

Total number of neighbors 1
R2#
```

Rys. 9: Wynik wykonania *show ip bgp summary* na **R2**

```
R3# show ip bgp summary

IPv4 Unicast Summary (VRF default):
BGP router identifier 3.3.3.3, local AS number 230 vrf-id 0
BGP table version 0
RIB entries 0, using 0 bytes of memory
Peers 1, using 718 KiB of memory

Neighbor        V         AS   MsgRcvd   MsgSent   TblVer  InQ OutQ  Up/Down State/PfxRcd   PfxSnt Desc
2.2.2.2         4        230         9         9        0    0    0 00:01:02            0        0 N/A

Total number of neighbors 1
R3#
```

Rys. 10: Wynik wykonania *show ip bgp summary* na **R3**

3.2. Zadanie C2

Zgodnie z poleceniem zestawiliśmy wszystkie wymagane sesje eBGP. Poniżej można zobaczyć zdjęcia z wyników wykonania komend *Show ip bgp summary* dla wszystkich routerów.

```
R1# show ip bgp summary

IPv4 Unicast Summary (VRF default):
BGP router identifier 1.1.1.1, local AS number 100 vrf-id 0
BGP table version 1
RIB entries 1, using 192 bytes of memory
Peers 1, using 718 KiB of memory

Neighbor        V         AS   MsgRcvd   MsgSent   TblVer  InQ OutQ  Up/Down State/PfxRcd   PfxSnt Desc
10.0.12.2       4        230         7         9        0    0    0 00:03:08            0        1 N/A

Total number of neighbors 1
R1#
```

Rys. 11: Wynik wykonania *show ip bgp summary* na **R1**

```
R2# show ip bgp summary

IPv4 Unicast Summary (VRF default):
BGP router identifier 2.2.2.2, local AS number 230 vrf-id 0
BGP table version 1
RIB entries 1, using 192 bytes of memory
Peers 3, using 2153 KiB of memory

Neighbor        V         AS   MsgRcvd   MsgSent   TblVer  InQ OutQ  Up/Down State/PfxRcd   PfxSnt Desc
3.3.3.3         4        230        46        50        0    0    0 00:39:53            0        1 N/A
10.0.12.1       4        100         7         7        0    0    0 00:03:15            1        1 N/A
10.0.24.2       4        400         5         6        0    0    0 00:01:38            0        1 N/A

Total number of neighbors 3
R2#
```

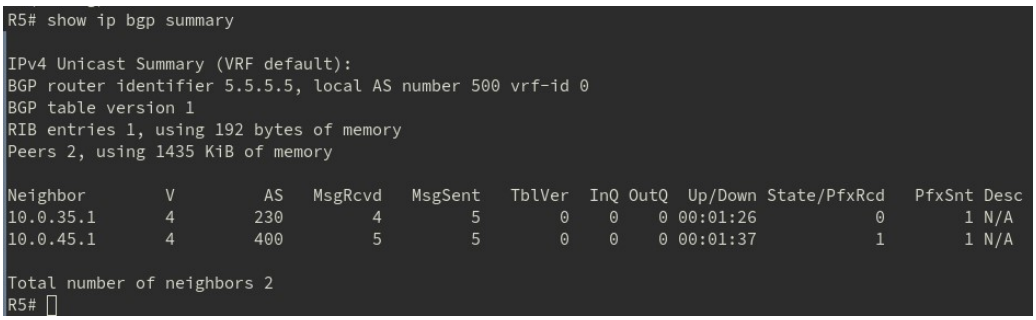
Rys. 12: Wynik wykonania *show ip bgp summary* na **R2**

```
R3# show ip bgp summary

IPv4 Unicast Summary (VRF default):
BGP router identifier 3.3.3.3, local AS number 230 vrf-id 0
BGP table version 0
RIB entries 1, using 192 bytes of memory
Peers 3, using 2153 KiB of memory

Neighbor        V         AS   MsgRcvd   MsgSent   TblVer  InQ OutQ  Up/Down State/PfxRcd   PfxSnt Desc
2.2.2.2         4        230        50        49        0    0    0 00:41:14            1        0 N/A
10.0.34.2       4        400         4         5        0    0    0 00:00:21            0        0 N/A
10.0.35.2       4        500         5         6        0    0    0 00:01:40            0        0 N/A

Total number of neighbors 3
R3#
```

Rys. 13: Wynik wykonania *show ip bgp summary* na **R3**

```
R4# show ip bgp summary

IPv4 Unicast Summary (VRF default):
BGP router identifier 4.4.4.4, local AS number 400 vrf-id 0
BGP table version 1
RIB entries 1, using 192 bytes of memory
Peers 3, using 2153 KiB of memory

Neighbor        V         AS   MsgRcvd   MsgSent   TblVer  InQ OutQ  Up/Down State/PfxRcd   PfxSnt Desc
10.0.24.1       4        230         6         6        0    0    0 00:02:54            1        1 N/A
10.0.34.1       4        230         3         4        0    0    0 00:00:16            0        1 N/A
10.0.45.2       4        500         5         6        0    0    0 00:01:46            0        1 N/A

Total number of neighbors 3
R4#
```

Rys. 14: Wynik wykonania *show ip bgp summary* na **R4**



Rys. 15: Wynik wykonania *show ip bgp summary* na **R5**

3.3. Zadanie C3

Zgodnie z poleceniem rozgłosiliśmy sieć kliencką z **R3**

```
R1# show ip bgp
BGP table version is 4, local router ID is 1.1.1.1, vrf id 0
Default local pref 100, local AS 100
Status codes:  s suppressed, d damped, h history, * valid, > best, = multipath,
               i internal, r RIB-failure, S Stale, R Removed
Nexthop codes: @NNN nexthop's vrf id, < announce-nh-self
Origin codes:  i - IGP, e - EGP, ? - incomplete
RPKI validation codes: V valid, I invalid, N Not found

    Network          Next Hop            Metric LocPrf Weight Path
 *> 192.168.111.0/24 0.0.0.0                  0         32768 i
 *> 192.168.131.0/24 10.0.12.2                             0 230 i

Displayed  2 routes and 2 total paths
```

Rys. 16: Wynik wykonania *show ip bgp* na **R1**

```
R1# show ip route bgp
Codes: K - kernel route, C - connected, S - static, R - RIP,
       O - OSPF, I - IS-IS, B - BGP, E - EIGRP, N - NHRP,
       T - Table, v - VNC, V - VNC-Direct, A - Babel, F - PBR,
       f - OpenFabric,
       > - selected route, * - FIB route, q - queued, r - rejected, b - backup
       t - trapped, o - offload failure

B>* 192.168.131.0/24 [20/0] via 10.0.12.2, eth1, weight 1, 00:02:36
```

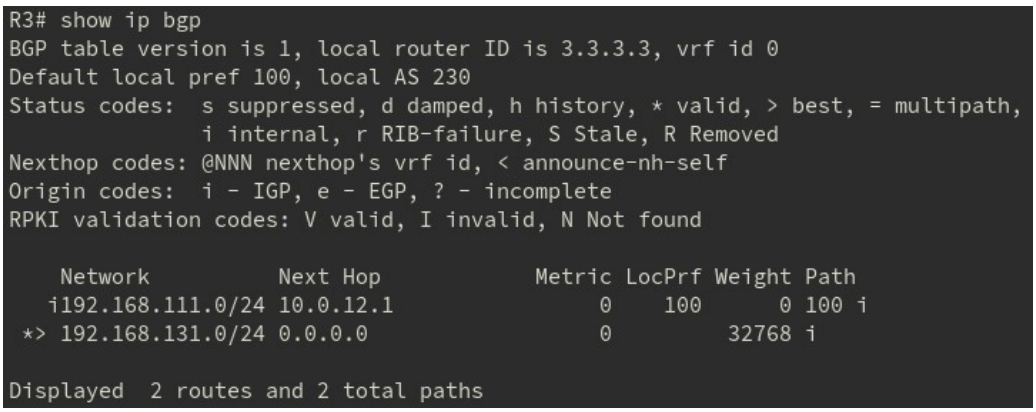
Rys. 17: Wynik wykonania *show ip route bgp* na **R1**

```
R2# show ip bgp
BGP table version is 4, local router ID is 2.2.2.2, vrf id 0
Default local pref 100, local AS 230
Status codes:  s suppressed, d damped, h history, * valid, > best, = multipath,
               i internal, r RIB-failure, S Stale, R Removed
Nexthop codes: @NNN nexthop's vrf id, < announce-nh-self
Origin codes:  i - IGP, e - EGP, ? - incomplete
RPKI validation codes: V valid, I invalid, N Not found

    Network          Next Hop            Metric LocPrf Weight Path
 *> 192.168.111.0/24 10.0.12.1                0             0 100 i
 *>i192.168.131.0/24 3.3.3.3                  0    100      0 i

Displayed  2 routes and 2 total paths
```

Rys. 18: Wynik wykonania *show ip bgp* na **R2**

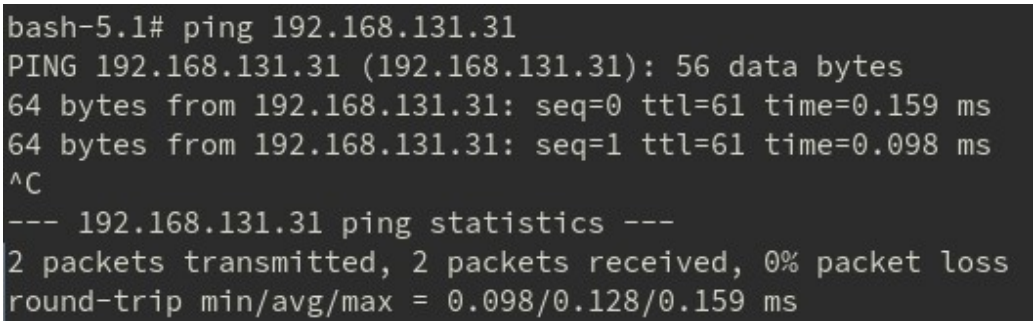
```
R2# show ip route bgp
Codes: K - kernel route, C - connected, S - static, R - RIP,
       O - OSPF, I - IS-IS, B - BGP, E - EIGRP, N - NHRP,
       T - Table, v - VNC, V - VNC-Direct, A - Babel, F - PBR,
       f - OpenFabric,
       > - selected route, * - FIB route, q - queued, r - rejected, b - backup
       t - trapped, o - offload failure

B>* 192.168.111.0/24 [20/0] via 10.0.12.1, eth1, weight 1, 00:01:03
B>  192.168.131.0/24 [200/0] via 3.3.3.3 (recursive), weight 1, 00:01:07
  *                          via 10.0.23.2, eth3, weight 1, 00:01:07
```

Rys. 19: Wynik wykonania *show ip route bgp* na **R2**

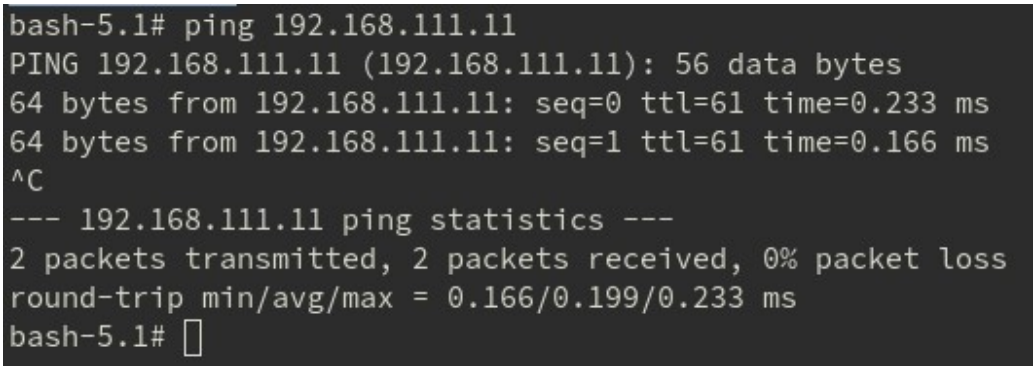


Rys. 20: Wynik wykonania *show ip bgp* na **R3**

Na **R3** można zauważyć, że parametr **next-hop** ustawiony jest na adres **10.0.12.2**. **R3** nie zna tego adresu, ponieważ iBGP działa na podstawie adresów loopback. Aby rozwiązać ten problem trzeba wykonać taką komendę *neighbor ¡iBGP neighbor IP addressgt; next-hop-self* na **R2**. Dzięki temu host z sieci klienckiej **R3** jest w stanie komunikować się z hostami z sieci klienckiej **R1** o czym świadczą poniższe wykonania *ping*.



Rys. 21: Wynik wykonania *ping* na **H11**



Rys. 22: Wynik wykonania *ping* na **H31**

```
R3# show ip bgp
BGP table version is 2, local router ID is 3.3.3.3, vrf id 0
Default local pref 100, local AS 230
Status codes:  s suppressed, d damped, h history, * valid, > best, = multipath,
               i internal, r RIB-failure, S Stale, R Removed
Nexthop codes: @NNN nexthop's vrf id, < announce-nh-self
Origin codes:  i - IGP, e - EGP, ? - incomplete
RPKI validation codes: V valid, I invalid, N Not found

    Network          Next Hop            Metric LocPrf Weight Path
 *>i192.168.111.0/24 2.2.2.2                  0    100      0 100 i
 *> 192.168.131.0/24 0.0.0.0                  0         32768 i

Displayed  2 routes and 2 total paths
```

Rys. 23: Wynik wykonania *show ip bgp* na **R3** (po zmianach)

```
R3# show ip route bgp
Codes: K - kernel route, C - connected, S - static, R - RIP,
       O - OSPF, I - IS-IS, B - BGP, E - EIGRP, N - NHRP,
       T - Table, v - VNC, V - VNC-Direct, A - Babel, F - PBR,
       f - OpenFabric,
       > - selected route, * - FIB route, q - queued, r - rejected, b - backup
       t - trapped, o - offload failure

B>  192.168.111.0/24 [200/0] via 2.2.2.2 (recursive), weight 1, 00:07:51
  *                            via 10.0.23.1, eth1, weight 1, 00:07:51
```

Rys. 24: Wynik wykonania *show ip route bgp* na **R3** (po zmianach)

3.4. Zadanie C4

```
R1# show ip bgp
BGP table version is 17, local router ID is 1.1.1.1, vrf id 0
Default local pref 100, local AS 100
Status codes:  s suppressed, d damped, h history, * valid, > best, = multipath,
               i internal, r RIB-failure, S Stale, R Removed
Nexthop codes: @NNN nexthop's vrf id, < announce-nh-self
Origin codes:  i - IGP, e - EGP, ? - incomplete
RPKI validation codes: V valid, I invalid, N Not found

    Network          Next Hop            Metric LocPrf Weight Path
 *> 192.168.111.0/24 0.0.0.0                  0         32768 i
 *> 192.168.131.0/24 10.0.12.2                             0 230 i
 *> 192.168.150.0/24 10.0.12.2                             0 230 500 i

Displayed  3 routes and 3 total paths
R1#
```

Rys. 25: Wynik wykonania *show ip bgp* na **R1**

```
R1# show ip route bgp
Codes: K - kernel route, C - connected, S - static, R - RIP,
       O - OSPF, I - IS-IS, B - BGP, E - EIGRP, N - NHRP,
       T - Table, v - VNC, V - VNC-Direct, A - Babel, F - PBR,
       f - OpenFabric,
       > - selected route, * - FIB route, q - queued, r - rejected, b - backup
       t - trapped, o - offload failure

B>* 192.168.131.0/24 [20/0] via 10.0.12.2, eth1, weight 1, 02:17:29
B>* 192.168.150.0/24 [20/0] via 10.0.12.2, eth1, weight 1, 00:51:03
```

Rys. 26: Wynik wykonania *show ip rotue bgp* na **R1**

```
R2# show ip bgp
BGP table version is 17, local router ID is 2.2.2.2, vrf id 0
Default local pref 100, local AS 230
Status codes:  s suppressed, d damped, h history, * valid, > best, = multipath,
               i internal, r RIB-failure, S Stale, R Removed
Nexthop codes: @NNN nexthop's vrf id, < announce-nh-self
Origin codes:  i - IGP, e - EGP, ? - incomplete
RPKI validation codes: V valid, I invalid, N Not found

    Network          Next Hop            Metric LocPrf Weight Path
 *> 192.168.111.0/24 10.0.12.1                0             0 100 i
 *>i192.168.131.0/24 3.3.3.3                  0    100      0 i
 *  192.168.150.0/24 10.0.24.2                               0 400 500 i
 *>i                 3.3.3.3                  0    100      0 500 i

Displayed  3 routes and 4 total paths
R2#
```

Rys. 27: Wynik wykonania *show ip bgp* na **R2**

```
R2# show ip route bgp
Codes: K - kernel route, C - connected, S - static, R - RIP,
       O - OSPF, I - IS-IS, B - BGP, E - EIGRP, N - NHRP,
       T - Table, v - VNC, V - VNC-Direct, A - Babel, F - PBR,
       f - OpenFabric,
       > - selected route, * - FIB route, q - queued, r - rejected, b - backup
       t - trapped, o - offload failure

B>* 192.168.111.0/24 [20/0] via 10.0.12.1, eth1, weight 1, 02:18:31
B>  192.168.131.0/24 [200/0] via 3.3.3.3 (recursive), weight 1, 02:18:35
  *                          via 10.0.23.2, eth3, weight 1, 02:18:35
B>  192.168.150.0/24 [200/0] via 3.3.3.3 (recursive), weight 1, 00:52:08
  *                          via 10.0.23.2, eth3, weight 1, 00:52:08
```

Rys. 28: Wynik wykonania *show ip route bgp* na **R2**

```
R3# show ip bgp
BGP table version is 15, local router ID is 3.3.3.3, vrf id 0
Default local pref 100, local AS 230
Status codes:  s suppressed, d damped, h history, * valid, > best, = multipath,
               i internal, r RIB-failure, S Stale, R Removed
Nexthop codes: @NNN nexthop's vrf id, < announce-nh-self
Origin codes:  i - IGP, e - EGP, ? - incomplete
RPKI validation codes: V valid, I invalid, N Not found

    Network          Next Hop            Metric LocPrf Weight Path
 *>i192.168.111.0/24 2.2.2.2                  0    100      0 100 i
 *> 192.168.131.0/24 0.0.0.0                  0         32768 i
 *  192.168.150.0/24 10.0.34.2                               0 400 500 i
 *>                  10.0.35.2                 0              0 500 i

Displayed  3 routes and 4 total paths
R3#
```

Rys. 29: Wynik wykonania *show ip bgp* na **R3**

```
R3# show ip route bgp
Codes: K - kernel route, C - connected, S - static, R - RIP,
       O - OSPF, I - IS-IS, B - BGP, E - EIGRP, N - NHRP,
       T - Table, v - VNC, V - VNC-Direct, A - Babel, F - PBR,
       f - OpenFabric,
       > - selected route, * - FIB route, q - queued, r - rejected, b - backup
       t - trapped, o - offload failure

B>  192.168.111.0/24 [200/0] via 2.2.2.2 (recursive), weight 1, 02:12:47
  *                          via 10.0.23.1, eth1, weight 1, 02:12:47
B>* 192.168.150.0/24 [20/0] via 10.0.35.2, eth3, weight 1, 00:53:04
```

Rys. 30: Wynik wykonania *show ip rotue bgp* na **R3**

```
R4# show ip bgp
BGP table version is 23, local router ID is 4.4.4.4, vrf id 0
Default local pref 100, local AS 400
Status codes:  s suppressed, d damped, h history, * valid, > best, = multipath,
               i internal, r RIB-failure, S Stale, R Removed
Nexthop codes: @NNN nexthop's vrf id, < announce-nh-self
Origin codes:  i - IGP, e - EGP, ? - incomplete
RPKI validation codes: V valid, I invalid, N Not found

    Network          Next Hop            Metric LocPrf Weight Path
 *  192.168.111.0/24 10.0.45.2                               0 500 230 100 i
 *=                  10.0.34.1                               0 230 100 i
 *>                  10.0.24.1                               0 230 100 i
 *  192.168.131.0/24 10.0.45.2                               0 500 230 i
 *=                  10.0.24.1                               0 230 i
 *>                  10.0.34.1                0              0 230 i
 *  192.168.150.0/24 10.0.24.1                               0 230 500 i
 *                   10.0.34.1                               0 230 500 i
 *>                  10.0.45.2                0              0 500 i

Displayed  3 routes and 9 total paths
R4#
```

Rys. 31: Wynik wykonania *show ip bgp* na **R4**

```
R4# show ip route bgp
Codes: K - kernel route, C - connected, S - static, R - RIP,
       O - OSPF, I - IS-IS, B - BGP, E - EIGRP, N - NHRP,
       T - Table, v - VNC, V - VNC-Direct, A - Babel, F - PBR,
       f - OpenFabric,
       > - selected route, * - FIB route, q - queued, r - rejected, b - backup
       t - trapped, o - offload failure

B>* 192.168.111.0/24 [20/0] via 10.0.24.1, eth1, weight 1, 02:13:53
  *                         via 10.0.34.1, eth2, weight 1, 02:13:53
B>* 192.168.131.0/24 [20/0] via 10.0.24.1, eth1, weight 1, 02:20:36
  *                         via 10.0.34.1, eth2, weight 1, 02:20:36
B>* 192.168.150.0/24 [20/0] via 10.0.45.2, eth3, weight 1, 00:54:10
```

Rys. 32: Wynik wykonania *show ip rotue bgp* na **R4**

```
R5# show ip bgp
BGP table version is 14, local router ID is 5.5.5.5, vrf id 0
Default local pref 100, local AS 500
Status codes:  s suppressed, d damped, h history, * valid, > best, = multipath,
               i internal, r RIB-failure, S Stale, R Removed
Nexthop codes: @NNN nexthop's vrf id, < announce-nh-self
Origin codes:  i - IGP, e - EGP, ? - incomplete
RPKI validation codes: V valid, I invalid, N Not found

    Network          Next Hop            Metric LocPrf Weight Path
 *> 192.168.111.0/24 10.0.35.1                               0 230 100 i
 *                   10.0.45.1                               0 400 230 100 i
 *  192.168.131.0/24 10.0.45.1                               0 400 230 i
 *>                  10.0.35.1                0              0 230 i
 *> 192.168.150.0/24 0.0.0.0                  0          32768 i

Displayed  3 routes and 5 total paths
R5#
```

Rys. 33: Wynik wykonania *show ip bgp* na **R5**

```
R5# show ip route bgp
Codes: K - kernel route, C - connected, S - static, R - RIP,
       O - OSPF, I - IS-IS, B - BGP, E - EIGRP, N - NHRP,
       T - Table, v - VNC, V - VNC-Direct, A - Babel, F - PBR,
       f - OpenFabric,
       > - selected route, * - FIB route, q - queued, r - rejected, b - backup
       t - trapped, o - offload failure

B>* 192.168.111.0/24 [20/0] via 10.0.35.1, eth2, weight 1, 02:15:04
B>* 192.168.131.0/24 [20/0] via 10.0.35.1, eth2, weight 1, 02:21:48
```

Rys. 34: Wynik wykonania *show ip rotue bgp* na **R5**

```
▸ Frame 8: 118 bytes on wire (944 bits), 118 bytes captured (944 bits) on interface -, id 0
▸ Ethernet II, Src: aa:c1:ab:05:1e:8b (aa:c1:ab:05:1e:8b), Dst: aa:c1:ab:2f:93:0b (aa:c1:ab:2f:93:0b)
▸ Internet Protocol Version 4, Src: 10.0.12.2, Dst: 10.0.12.1
▸ Transmission Control Protocol, Src Port: 39814, Dst Port: 179, Seq: 20, Ack: 20, Len: 52
▾ Border Gateway Protocol - UPDATE Message
    Marker: ffffffffffffffffffffffffffffffff
    Length: 52
    Type: UPDATE Message (2)
    Withdrawn Routes Length: 0
    Total Path Attribute Length: 25
  ▾ Path attributes
    ▸ Path Attribute - ORIGIN: IGP
    ▸ Path Attribute - AS_PATH: 230 500
    ▸ Path Attribute - NEXT_HOP: 10.0.12.2
  ▾ Network Layer Reachability Information (NLRI)
    ▸ 192.168.150.0/24
```

Rys. 35: Zawartość wiadomości UPDATE

```
bash-5.1# traceroute 192.168.150.200
traceroute to 192.168.150.200 (192.168.150.200), 30 hops max, 46 byte packets
 1  192.168.111.1 (192.168.111.1)  0.008 ms  0.011 ms  0.008 ms
 2  10.0.12.2 (10.0.12.2)  0.007 ms  0.011 ms  0.007 ms
 3  10.0.23.2 (10.0.23.2)  0.007 ms  0.012 ms  0.011 ms
 4  10.0.35.2 (10.0.35.2)  0.008 ms  0.010 ms  0.007 ms
 5  192.168.150.200 (192.168.150.200)  0.007 ms  0.009 ms  0.006 ms
bash-5.1# traceroute 192.168.150.100
traceroute to 192.168.150.100 (192.168.150.100), 30 hops max, 46 byte packets
 1  192.168.111.1 (192.168.111.1)  0.007 ms  0.014 ms  0.012 ms
 2  10.0.12.2 (10.0.12.2)  0.012 ms  0.016 ms  0.012 ms
 3  10.0.23.2 (10.0.23.2)  0.012 ms  0.009 ms  0.007 ms
 4  10.0.35.2 (10.0.35.2)  0.007 ms  0.017 ms  0.013 ms
 5  192.168.150.100 (192.168.150.100)  0.012 ms  0.068 ms  0.013 ms
```

Rys. 36: Wynik wykonania *traceroute* na **H11** do **H51** i **H52**

podstawie powyższych zdjęć można stwierdzić, że udało nam się poprawnie rozgłosić z agregowany adres **192.168.150.0/24**. Na podstawie wiadomości **UPDATE** można też zaobserwoać, jakiego typy informacje są przekazywane między routerami podczas rozgłaszania sieci, jest to między innymi atrybut **AS-PATH**, który zawiera listę obszarów AS, przez które trzeba przejść aby dotrzeć do rozgłaszanej sieci oraz atrybut **NEXT_HOP**, który zawiera informację o tym, do którego routera trzeba przesłać pakiety.

3.5. Zadanie C5

```
bash-5.1# traceroute 192.168.141.41
traceroute to 192.168.141.41 (192.168.141.41), 30 hops max, 46 byte packets
 1  192.168.111.1 (192.168.111.1)  0.008 ms  0.015 ms  0.012 ms
 2  10.0.12.2 (10.0.12.2)  0.012 ms  0.017 ms  0.012 ms
 3  10.0.24.2 (10.0.24.2)  0.012 ms  0.016 ms  0.013 ms
 4  192.168.141.41 (192.168.141.41)  0.225 ms  0.016 ms  0.014 ms
```

Rys. 37: Wynik wykonania *traceroute* na **H11** do **H41**

Jak można zauważyć na powyższym zdjęciu ruch pakietów świeżo po rozgłoszeniu sieci klienckiej **R4** odbywa się po drodze między **R2** a **R4**. Zgodnie z założeniami zadania postanowiliśmy zmienić tą trasę tak, żeby ruch kierowany do sieci klienckiej **192.168.141.0/24** odbywał się na drodze **R2** → **R3** → **R4**. W tym celu na **R2** utworzyliśmy **route-map** dzięki, któremu blokujemy na łączu **R2, R4** ruch skierowany z oraz do wcześniej wskazanej sieci. Na poniższych zdjęciach można zobaczyć dokładny proces implementacji tego rozwiązania.

```
R2(config)# ip prefix-list Filter seq 5 permit 192.168.141.0/24
R2(config)# route-map Filter deny 10
R2(config-route-map)# match ip address prefix-list Filter
R2(config-route-map)# ex
R2(config)# route-map Filter permit 20
R2(config-route-map)# end
```

Rys. 38: Konfiguracja **R2** (cz.1)

```
BGP:
route-map: Filter Invoked: 0 Optimization: enabled Processed Change: false
 deny, sequence 10 Invoked 0
  Match clauses:
    ip address prefix-list Filter
  Set clauses:
  Call clause:
  Action:
    Exit routemap
 permit, sequence 20 Invoked 0
  Match clauses:
  Set clauses:
  Call clause:
  Action:
    Exit routemap
R2# conf terminal
R2(config)# router bgp 230
R2(config-router)# neighbor 10.0.24.2 route-map Filter out
R2(config-router)# no neighbor 10.0.24.2 route-map Filter out
R2(config-router)# neighbor 10.0.24.2 route-map Filter in
R2(config-router)#
```

Rys. 39: Konfiguracja **R2** (cz.2)

Jak można zauważyć na poniższych zdjęciach ruch skierowany do sieci **192.168.141.0/24** odbywa się poprzez **R3**, przy czym ruch skierowany do sieci **192.168.150/24** porusza się dalej tak samo jak wcześniej.

```
bash-5.1# traceroute 192.168.141.41
traceroute to 192.168.141.41 (192.168.141.41), 30 hops max, 46 byte packets
 1  192.168.111.1 (192.168.111.1)  0.007 ms  0.016 ms  0.006 ms
 2  10.0.12.2 (10.0.12.2)  0.005 ms  0.040 ms  0.005 ms
 3  10.0.23.2 (10.0.23.2)  0.005 ms  0.009 ms  0.006 ms
 4  10.0.34.2 (10.0.34.2)  0.006 ms  0.054 ms  0.007 ms
 5  192.168.141.41 (192.168.141.41)  0.006 ms  0.009 ms  0.006 ms
bash-5.1# traceroute 192.168.150.100
traceroute to 192.168.150.100 (192.168.150.100), 30 hops max, 46 byte packets
 1  192.168.111.1 (192.168.111.1)  0.008 ms  0.011 ms  0.009 ms
 2  10.0.12.2 (10.0.12.2)  0.008 ms  0.008 ms  0.006 ms
 3  10.0.23.2 (10.0.23.2)  0.006 ms  0.011 ms  0.007 ms
 4  10.0.35.2 (10.0.35.2)  0.006 ms  0.010 ms  0.008 ms
 5  192.168.150.100 (192.168.150.100)  0.011 ms  0.021 ms  0.016 ms
bash-5.1# traceroute 192.168.150.200
traceroute to 192.168.150.200 (192.168.150.200), 30 hops max, 46 byte packets
 1  192.168.111.1 (192.168.111.1)  0.010 ms  0.008 ms  0.006 ms
 2  10.0.12.2 (10.0.12.2)  0.007 ms  0.011 ms  0.009 ms
 3  10.0.23.2 (10.0.23.2)  0.007 ms  0.008 ms  0.006 ms
 4  10.0.35.2 (10.0.35.2)  0.005 ms  0.008 ms  0.006 ms
 5  192.168.150.200 (192.168.150.200)  0.012 ms  0.008 ms  0.029 ms
bash-5.1#
```

Rys. 40: Wynik wykonania *traceoute* na **H11** do **H41, H51** oraz **H52**

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000	10.0.23.2	224.0.0.5	OSPF	82	Hello Packet
2	2.165884	10.0.23.1	224.0.0.5	OSPF	82	Hello Packet
3	2.935126	2.2.2.2	3.3.3.3	BGP	85	KEEPALIVE Message
4	2.935394	3.3.3.3	2.2.2.2	BGP	85	KEEPALIVE Message
5	2.935402	2.2.2.2	3.3.3.3	TCP	66	33711 → 179 [ACK] Seq=20 Ack=20 Win=443 Len=0 TSval=687260041 TSecr=1897439708
6	7.990545	aa:c1:ab:65:18:be	aa:c1:ab:32:f4:b5	ARP	42	Who has 10.0.23.2? Tell 10.0.23.1
7	7.990599	aa:c1:ab:32:f4:b5	aa:c1:ab:65:18:be	ARP	42	Who has 10.0.23.1? Tell 10.0.23.2
8	7.990609	aa:c1:ab:65:18:be	aa:c1:ab:32:f4:b5	ARP	42	10.0.23.1 is at aa:c1:ab:65:18:be
9	7.990661	aa:c1:ab:32:f4:b5	aa:c1:ab:65:18:be	ARP	42	10.0.23.2 is at aa:c1:ab:32:f4:b5
10	9.381735	192.168.111.11	192.168.141.41	ICMP	98	Echo (ping) request id=0x0032, seq=0/0, ttl=62 (reply in 11)
11	9.381778	192.168.141.41	192.168.111.11	ICMP	98	Echo (ping) reply id=0x0032, seq=0/0, ttl=62 (request in 10)
12	10.014007	10.0.23.2	224.0.0.5	OSPF	82	Hello Packet
13	10.381911	192.168.111.11	192.168.141.41	ICMP	98	Echo (ping) request id=0x0032, seq=1/256, ttl=62 (reply in 14)
14	10.381939	192.168.141.41	192.168.111.11	ICMP	98	Echo (ping) reply id=0x0032, seq=1/256, ttl=62 (request in 13)
15	11.453769	192.168.111.11	192.168.141.41	ICMP	98	Echo (ping) request id=0x0032, seq=2/512, ttl=62 (reply in 16)
16	11.453803	192.168.141.41	192.168.111.11	ICMP	98	Echo (ping) reply id=0x0032, seq=2/512, ttl=62 (request in 15)
17	12.166269	10.0.23.1	224.0.0.5	OSPF	82	Hello Packet
18	12.454389	192.168.111.11	192.168.141.41	ICMP	98	Echo (ping) request id=0x0032, seq=3/768, ttl=62 (reply in 19)
19	12.454426	192.168.141.41	192.168.111.11	ICMP	98	Echo (ping) reply id=0x0032, seq=3/768, ttl=62 (request in 18)
20	13.455066	192.168.111.11	192.168.141.41	ICMP	98	Echo (ping) request id=0x0032, seq=4/1024, ttl=62 (reply in 21)
21	13.455107	192.168.141.41	192.168.111.11	ICMP	98	Echo (ping) reply id=0x0032, seq=4/1024, ttl=62 (request in 20)
22	14.456579	192.168.111.11	192.168.141.41	ICMP	98	Echo (ping) request id=0x0032, seq=5/1280, ttl=62 (reply in 23)
23	14.456613	192.168.141.41	192.168.111.11	ICMP	98	Echo (ping) reply id=0x0032, seq=5/1280, ttl=62 (request in 22)
24	20.014066	10.0.23.2	224.0.0.5	OSPF	82	Hello Packet

Rys. 41: Ruch powstały na łączu **R2, R3** w trakcie wykonania komendy *ping* na **H11** do **H41**

```
R2# show ip bgp
BGP table version is 7, local router ID is 2.2.2.2, vrf id 0
Default local pref 100, local AS 230
Status codes:  s suppressed, d damped, h history, * valid, > best, = multipath,
               i internal, r RIB-failure, S Stale, R Removed
Nexthop codes: @NNN nexthop's vrf id, < announce-nh-self
Origin codes:  i - IGP, e - EGP, ? - incomplete
RPKI validation codes: V valid, I invalid, N Not found

    Network          Next Hop            Metric LocPrf Weight Path
 *> 192.168.111.0/24 10.0.12.1                0             0 100 i
 *>i192.168.131.0/24 3.3.3.3                  0    100      0 i
 *>i192.168.141.0/24 3.3.3.3                  0    100      0 400 i
 *  192.168.150.0/24 10.0.24.2                               0 400 500 i
 *>i                 3.3.3.3                  0    100      0 500 i

Displayed  4 routes and 5 total paths
R2#
```

Rys. 42: Wynik wykonania *show ip bgp* na **R2**

3.6. Zadanie C6

Zgodnie z poleceniem mieliśmy sprawić z wykorzystaniem techniki **path prepending** aby ruch skierowany do sieci **192.168.150.0/24** przechodził przez **AS 400**. W tym celu tak jak w poprzednim podpunkcie stworzyliśmy odpowiednią mapę na **R5**. Tym razem mapa ta nie blokowała żadnego ruchu tylko sprawiała, że połączenie **R3, R5** było mniej atrakcyjne (poprzez jej "sztuczne" wydłużenie) dla algorytmu doboru najlepszej ścieżki dlatego w ostateczności pakiety były przesyłane przez **AS400**. Ponownie sam proces implementacji oraz rezultaty można zobaczyć na poniższych zdjęciach.

```
R5(config)# ip prefix-list PathPrepending seq 5 permit 192.168.150.0/24
R5(config)# route-map PathPrepending permit 10
R5(config-route-map)# match ip address prefix-list PathPrepending
R5(config-route-map)# set as-path prepend 400 400 400 400 400
R5(config-route-map)# ex
R5(config)# router bgp 500
R5(config-router)# neighbor 10.0.35.1 route-map PathPrepending out
```

Rys. 43: Konfiguracja **R5**

```
bash-5.1# traceroute 192.168.150.100
traceroute to 192.168.150.100 (192.168.150.100), 30 hops max, 46 byte packets
 1  192.168.111.1 (192.168.111.1)  0.008 ms  0.019 ms  0.018 ms
 2  10.0.12.2 (10.0.12.2)  0.018 ms  0.018 ms  0.013 ms
 3  10.0.23.2 (10.0.23.2)  0.012 ms  0.008 ms  0.005 ms
 4  10.0.34.2 (10.0.34.2)  0.006 ms  0.018 ms  0.012 ms
 5  10.0.45.2 (10.0.45.2)  0.012 ms  0.020 ms  0.017 ms
 6  192.168.150.100 (192.168.150.100)  0.017 ms  0.010 ms  0.008 ms
bash-5.1#
```

Rys. 44: Wynik wykonania *traceroute* na **H11** do **H51**

```
R3# show ip bgp
BGP table version is 16, local router ID is 3.3.3.3, vrf id 0
Default local pref 100, local AS 230
Status codes:  s suppressed, d damped, h history, * valid, > best, = multipath,
               i internal, r RIB-failure, S Stale, R Removed
Nexthop codes: @NNN nexthop's vrf id, < announce-nh-self
Origin codes:  i - IGP, e - EGP, ? - incomplete
RPKI validation codes: V valid, I invalid, N Not found

    Network          Next Hop            Metric LocPrf Weight Path
 *>i192.168.111.0/24 2.2.2.2                  0    100      0 100 i
 *> 192.168.131.0/24 0.0.0.0                  0         32768 i
 *> 192.168.141.0/24 10.0.34.2                0             0 400 i
 *> 192.168.150.0/24 10.0.34.2                              0 400 500 i
 *                   10.0.35.2                0             0 500 400 400 400 400 400 i

Displayed  4 routes and 5 total paths
R3#
```

Rys. 45: Wynik wykonania *show ip bgp* na **R3**