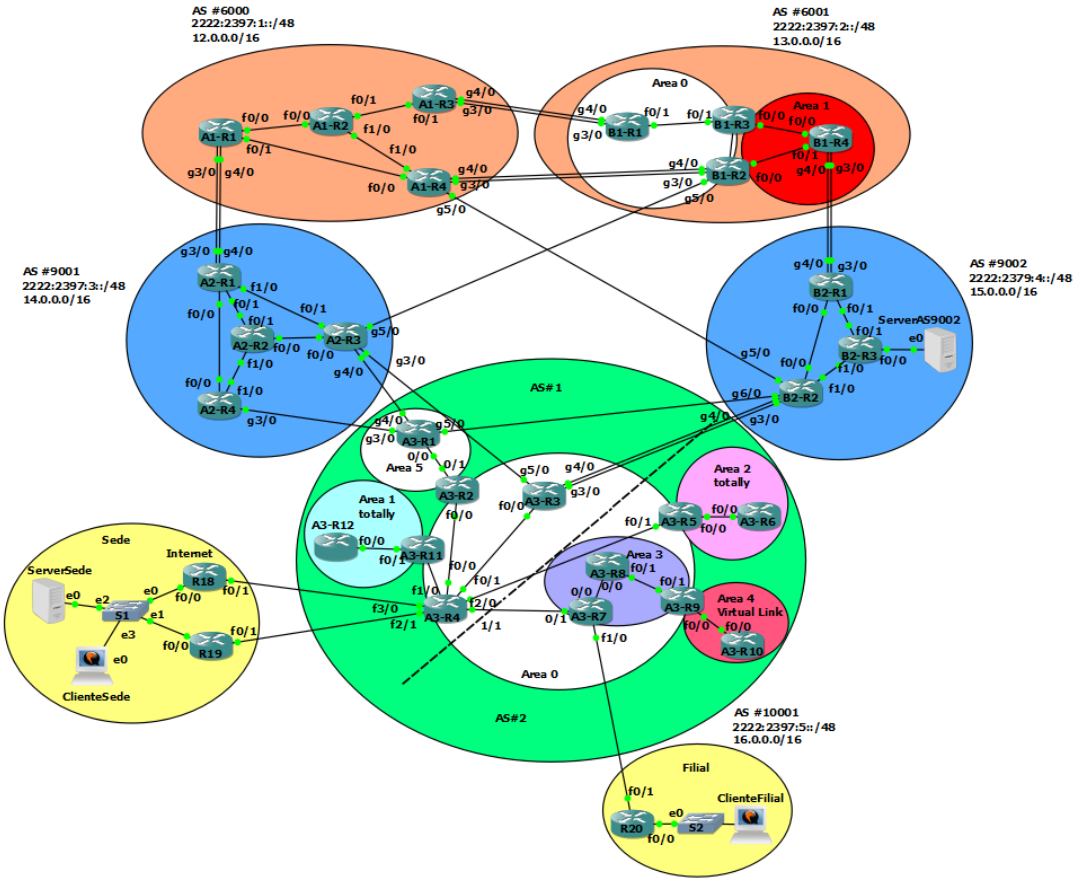


Tópicos Avançados De Redes

PROJETO GNS3

Miguel Lopes 2222397

Índice

Índica de Figuras

Topologia de Rede

- AS #6000

R1(Lo)	2222:2397:1::1/128	12.0.0.1/32
R2(Lo)	2222:2397:1::2/128	12.0.0.2/32
R3(Lo)	2222:2397:1::3/128	12.0.0.3/32
R4(Lo)	2222:2397:1::4/128	12.0.0.4/32
R1(fo/0) ->R2(fo/0)	2222:2397:1:1::/64	12.0.1.0/30
R2(fo/1) ->R3(fo/1)	2222:2397:1:2::/64	12.0.1.4/30
R2(f1/0) ->R4(f1/0)	2222:2397:1:3::/64	12.0.1.8/30
R1(fo/1) ->R4(fo/0)	2222:2397:1:4::/64	12.0.1.12/30
R1(g3/0) ->A2-R1(g3/0)	2222:2397:1:5::1/64	12.0.1.17/30
R1(g4/0) ->A2-R1(g4/0)	2222:2397:1:6::1/64	12.0.1.21/30
R3(g3/0) ->B1-R1(g3/0)	2222:2397:1:7::1/64	12.0.1.25/30
R3(g4/0) 3->B1-R1(g4/0)	2222:2397:1:8::1/64	12.0.1.29/30
R4(g3/0) ->B1-R2(g3/0)	2222:2397:1:9::1/64	12.0.1.33/30
R4(g4/0) ->B1-R2(g4/0)	2222:2397:1:A::1/64	12.0.1.37/30
R4(g5/0) ->B2-R2(g5/0)	2222:2397:1:B::1/64	12.0.1.41/30
Link-Local	FE80::6000:x	

- AS #6001

R1(Lo)	2222:2397:2::1/128	13.0.0.1/32
R2(Lo)	2222:2397:2::2/128	13.0.0.2/32
R3(Lo)	2222:2397:2::3/128	13.0.0.3/32
R4(Lo)	2222:2397:2::4/128	13.0.0.4/32
R1(fo/1) ->R3(fo/1)	2222:2397:2:1::/64	13.0.1.0/30
R2(f1/0) ->R3 (1/0)	2222:2397:2:2::/64	13.0.1.4/30
R3(fo/0) ->R4(fo/0)	2222:2397:2:3::/64	13.0.1.8/30
R2(fo/0) ->R4(fo/1)	2222:2397:2:4::/64	13.0.1.12/30
B1-R1(g3/0) ->A1-R3(g3/0)	2222:2397:1:7::2/64	12.0.1.26/30
B1-R1(g4/0) ->A1-R3(g4/0)	2222:2397:1:8::2/64	12.0.1.30/30
B1-R4(g3/0) ->B2-R1(g3/0)	2222:2397:2:5::1/64	13.0.1.17/30
B1-R4(g4/0) ->B2-R1(g4/0)	2222:2397:2:6::1/64	13.0.1.21/30
B1-R2(g5/0) ->A2-R3(g5/0)	2222:2397:2:7::1/64	13.0.1.25/30
B1-R2(g3/0) ->A1-R4(g3/0)	2222:2397:1:9::2/64	12.0.1.34/30
B1-R2(g4/0) ->A1-R4(g4/0)	2222:2397:1:A::2/64	12.0.1.38/30
Link-Local	FE80::6001:x	

- AS #9001

R1(Lo)	2222:2397:3::1/128	14.0.0.1/32
R2(Lo)	2222:2397:3::2/128	14.0.0.2/32
R3(Lo)	2222:2397:3::3/128	14.0.0.3/32
R4(Lo)	2222:2397:3::4/128	14.0.0.4/32
R1(fo/1) ->R2(fo/1)	2222:2397:3:1::/64	14.0.1.0/30
R1(f1/0) ->R3(fo/1)	2222:2397:3:2::/64	14.0.1.4/30
R1(fo/0) ->R4(fo/0)	2222:2397:3:3::/64	14.0.1.8/30
R2(fo/0) ->R3(fo/0)	2222:2397:3:4::/64	14.0.1.12/30
R2(f1/0) ->R4(f1/0)	2222:2397:3:5::/64	14.0.1.16/30
R4(g3/0) ->A3-R1(g3/0)	2222:2397:3:6::1/64	14.0.1.21/30
R3(g4/0) ->A3-R1(g4/0)	2222:2397:3:7::1/64	14.0.1.25/30
R3(g3/0) ->A3-R3(g5/0)	2222:2397:3:8::1/64	14.0.1.29/30
A2-R3(g5/0)->B1-R2(g5/0)	2222:2397:2:7::2/64	13.0.1.26/30
A2-R1(g3/0) ->A1-R1(g3/0)	2222:2397:1:5::2/64	12.0.1.18/30
A2-R1(g4/0) ->A1-R1(g4/0)	2222:2397:1:6::2/64	12.0.1.22/30
Link-Local	FE80::9001:x	

- AS #9002

R1(Lo)	2222:2397:4::1/128	15.0.0.1/32
R2(Lo)	2222:2397:4::2/128	15.0.0.2/32
R3(Lo)	2222:2397:4::3/128	15.0.0.3/32
R1(fo/0) ->R2(fo/0)	2222:2397:4:1::/64	15.0.1.0/30
R1(fo/1) ->R3(fo/1)	2222:2397:4:2::/64	15.0.1.4/30
R2(f1/0) ->R3(f1/0)	2222:2397:4:3::/64	15.0.1.8/30
R2(g6/0) ->A3-R1(g5/0)	2222:2397:4:4::1/64	15.0.1.13/30
R2(g3/0) ->A3-R3(g3/0)	2222:2397:4:5::1/64	15.0.1.17/30
R2(g4/0) ->A3-R3(g4/0)	2222:2397:4:6::1/64	15.0.1.21/30
B2-R2(g5/0) ->A1-R4(g5/0)	2222:2397:1:B::2/64	12.0.1.42/30
B2-R1(g3/0) ->B1-R4(g3/0)	2222:2397:2:5::2/64	13.0.1.18/30
B2-R1(g4/0) ->B1-R4(g4/0)	2222:2397:2:6::2/64	13.0.1.22/30
B2-R2(fo/0) ->ServerAS9002	2222:2397:4:7::1/64	15.0.2.1/24
ServerAS9002	2222:2397:4:7::2/64	15.0.2.2/24
Link-Local	FE80::9002:x	

- AS #10001

R1(L0)	2222:2397:5::1/128	16.0.0.1/32
R2(L0)	2222:2397:5::2/128	16.0.0.2/32
R3(L0)	2222:2397:5::3/128	16.0.0.3/32
R4(L0)	2222:2397:5::4/128	16.0.0.4/32
R5(L0)	2222:2397:5::5/128	16.0.0.5/32
R6(L0)	2222:2397:5::6/128	16.0.0.6/32
R7(L0)	2222:2397:5::7/128	16.0.0.7/32
R8(L0)	2222:2397:5::8/128	16.0.0.8/32
R9(L0)	2222:2397:5::9/128	16.0.0.9/32
R10(L0)	2222:2397:5::A/128	16.0.0.10/32
R11(L0)	2222:2397:5::B/128	16.0.0.11/32
R12(L0)	2222:2397:5::C/128	16.0.0.12/32
R1(f0/0) ->R2(f0/1)	2222:2397:5:1::/64	16.0.1.0/30
R2(f0/1) ->R4(f0/0)	2222:2397:5:2::/64	16.0.1.4/30
R3(f0/0) ->R4(f0/1)	2222:2397:5:3::/64	16.0.1.8/30
R4(2/0) ->R5(f0/1)	2222:2397:5:4::/64	16.0.1.12/30
R5(f0/0) ->R6(f0/0)	2222:2397:5:5::/64	16.0.1.16/30
R4(f1/1) ->R7(f0/1)	2222:2397:5:6::/64	16.0.1.20/30
R7(f0/0) ->R8(f0/0)	2222:2397:5:7::/64	16.0.1.24/30
R8(f0/1) ->R9(f0/1)	2222:2397:5:8::/64	16.0.1.28/30
R9(f0/0) ->R10(f0/0)	2222:2397:5:9::/64	16.0.1.32/30
R4(f1/0) ->R11(f0/0)	2222:2397:5:A::/64	16.0.1.36/30
R11(f0/1) ->R12(f0/0)	2222:2397:5:B::/64	16.0.1.40/30
A3-R1(g5/0) ->B2-R2(g6/0)	2222:2397:4:4::2/64	15.0.1.14/30
A3-R1(g3/0) ->A2-R4(g3/0)	2222:2397:3:6::2/64	14.0.1.22/30
A3-R1(g4/0) ->A2-R3(g4/0)	2222:2397:3:7::2/64	14.0.1.26/30
A3-R3(g5/0) ->A2-R3(g3/0)	2222:2397:3:8::2/64	14.0.1.30/30
A3-R3(g3/0) ->B2-R2(g3/0)	2222:2397:4:5::2/64	15.0.1.18/30
A3-R3(g4/0) ->B2-R2(g4/0)	2222:2397:4:6::2/64	15.0.1.22/30
R4(f3/0) ->R18(f0/1)	-	16.0.1.46/30
R4(f2/1) ->R19(f0/1)	-	192.168.0.1/30
R4(L1)	-	16.16.16.1/32
R7(f1/0) ->R20(f0/1)	-	192.168.0.5/30
R7(L1)	-	16.16.16.2/32
Link-Local	FE80::1:1:x	

- Sede

R18(internet)	
-fo/o	172.16.2.4
-fo/1(r4)	16.0.1.45
ServerSede	172.16.2.3
ClienteSede	DHCP
R19	
-fo/o	172.16.2.1/24
-fo/1(r4)	192.168.0.2/30
-Lo	172.16.0.1/32

- Filial

R20	
-fo/o	172.16.3.1/24
-fo/1	192.168.0.6/32
-Lo	172.16.0.2/32
ClienteFilial	DHCP

Tipos de configurações efetuadas

- IGP
  - Tier 1 A

- OSPFv3 AF single área (0)

  - Tier 1 B

- OSPFv3 AF multiárea 0 e 1

  - Tier 2 A

- OSPFv3 AF single área (0)

  - Tier 2 B

-rip (ipv4 e ipv6)

  - Tier 3 A

- OSPFv3 AF multiárea e ospf:

  -area 0 -> Standard

  -area 1 -> Totally stub

  -area 2 -> Totally stub

  -area 3 -> Transit

  -area 4 -> virtual link

  -area 5 -> Standard

-OSPF 2:

-Implementado no router A3-R4(PE) para conhecimento das redes da Sede, por conta da VPN L3 MPLS.

-Implementado no router A3-R7(PE) para conhecimento das redes da Filial, por conta da VPN L3 MPLS.

➢ Sede e Filial

-R18->

-Assegura a conectividade à internet para qualquer equipamento dentro da empresa a partir de rotas por omissão.

-Implementação de Nat

-Implementação de router rip para conhecimento das redes da empresa, para haver redireccionamento.

-r19->

-Implementação de rip com o A3-R4(PE) para a criação da VPN L3 MPLS, para este conhecer e aprender as rotas.

-Implementação de Dhcp dentro da Sede

-R20->

-Implementação de ospf com o router A3R7 (PE) para a criação da VPN L3 MPLS, para este conhecer e aprender as rotas.

-Implementação de Dhcp dentro da Filial

❖ BGP

➢ Tier 1 A

-eBGP;

-iBGP;

-A1-R2 -> Router reflector

-BGP PathAttributes ->Local Preference

-120->rotas aprendidas via Tier 2 A. (Link preferencial para comunicação todos os tiers menos o Tier 1 B) e uso paralelo dos links.

-140-> rotas aprendidas via Tier 1 B com destino ao AS6001, pelo router A1-R3 e uso paralelo dos links. (Link preferencial para comunicação com o Tier 1 B)

-130-> rotas aprendidas via Tier 1 B com destino ao AS6001, pelo router A1-R4 e uso paralelo dos links.

- Tier 1 B

-eBGP;

-iBGP;

-B1-R3 -> Router reflector

-BGP PathAttributes ->Local Preference

-140-> rotas aprendidas via Tier 1 A com destino ao AS6000, pelo router B1-R1 e uso paralelo dos links. (Link preferencial para comunicação com o Tier 1 A).

-130-> rotas aprendidas via Tier 1 A com destino ao AS6000, pelo router B1-R2 e uso paralelo dos links.

-120->rotas aprendidas via Tier 2 B. (Link preferencial para comunicação todos os Tiers menos o Tier 1 A) e uso paralelo dos links.

- Tier 2 A

-eBGP;

-iBGP;

-A2-R2 -> Router reflector

-BGP PathAttributes ->Local Preference

-120->rotas aprendidas via Tier 1 A com destino aos Tiers 1 pelo router A2-R1 (Link preferencial para comunicação com os Tiers 1) e uso paralelo dos links.

- Tier 2 B

-eBGP;

-iBGP;

-B2-R3 -> Router reflector

-BGP PathAttributes ->Local Preference

-120->rotas aprendidas via Tier 1 B com destino aos Tiers 1 pelo router B2-R1 (Link preferencial para comunicação com os Tiers 1) e uso paralelo dos links.

-Uso paralelo dos links nas ligações com o Tier 3 A

- Tier 3 A

-eBGP;

-iBGP;

-Confederação 1 e 2

-A3-R4 -> Router reflector da confederação 1

-A3-R7 -> Router reflector da confederação 2

-BGP PathAttributes ->Local Preference

-120->rotas aprendidas via Tier 2A (Link preferencial para comunicação com todos os Tiers) e uso paralelo dos links.

-QoS -> em todo o sistema autónomo

Classe (MARCAR)	Critérios	Precedência IP	MPLS EXP	Tratamento (QOS_SAIDA)
PRIORITARIO	DNS, ICMP, HTTP	5	5	Largura de banda garantida (10%) - GOLD
GESTAO	TELNET, SSH	3	3	Largura de banda garantida (20%) - SILVER
TRANSFERENCIA	TFTP	2	2	Largura de banda garantida (40%) - BRONZE
class-default	Não categorizado	0	0	Fair-Queue

-MPLS -> em todos o sistema autónomo

- VPN L3 MPLS -> para ligação entre a Sede e a Filial

- VRFs nos routers A3R4 e A3R7 para a VPN do cliente A

➢ Sede e Filial

-QoS ->cliente empresarial

Classe (MARCAR)	Critérios	Precedência IP	MPLS EXP	Tratamento (QOS_SAIDA_EMPRESA)
PRIORITARIO	DNS, ICMP, HTTP	5	5	Largura de banda garantida (10%) - GOLD
GESTAO	TELNET, SSH	3	3	Largura de banda garantida (20%) - SILVER
TRANSFERENCIA	TFTP	2	2	Largura de banda garantida (25%) - BRONZE

TESTES DE CONECTIVIDADE

- VPN L3 MPLS

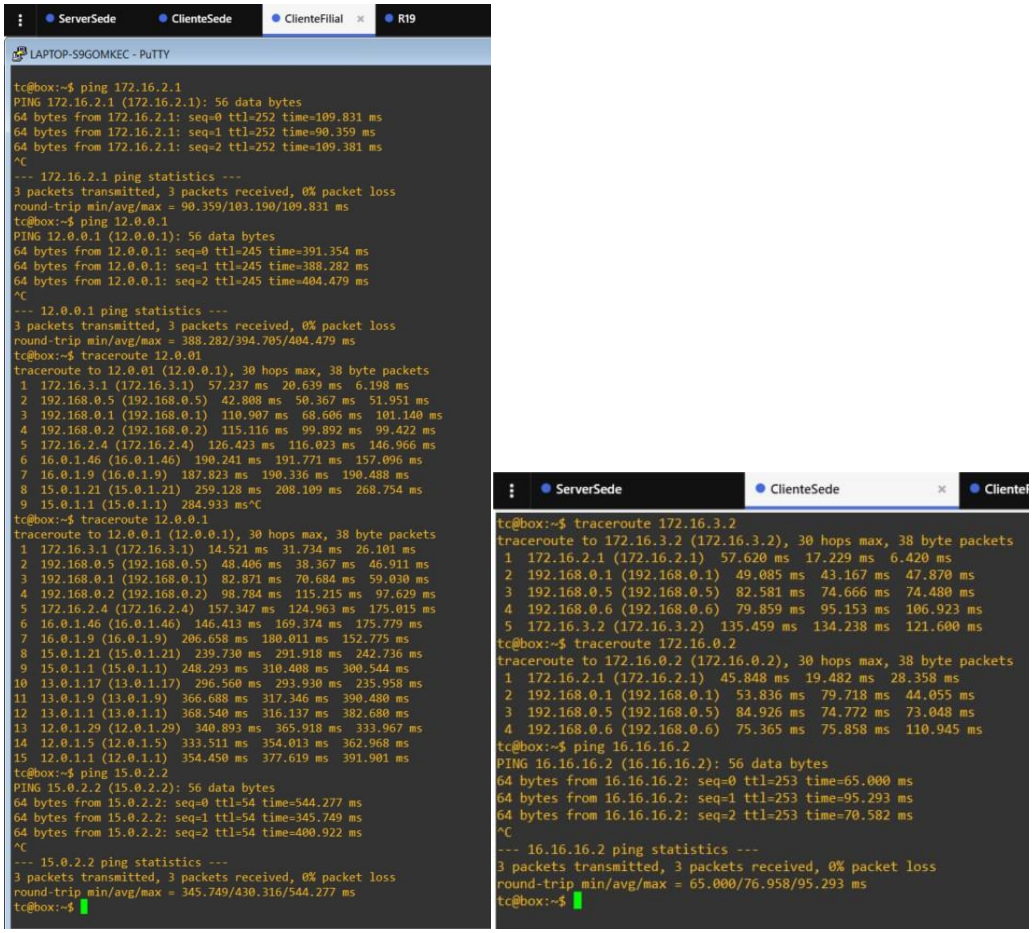


Figura 1- ClienteFilial-ServerAS9002 e ClienteSede-Filial

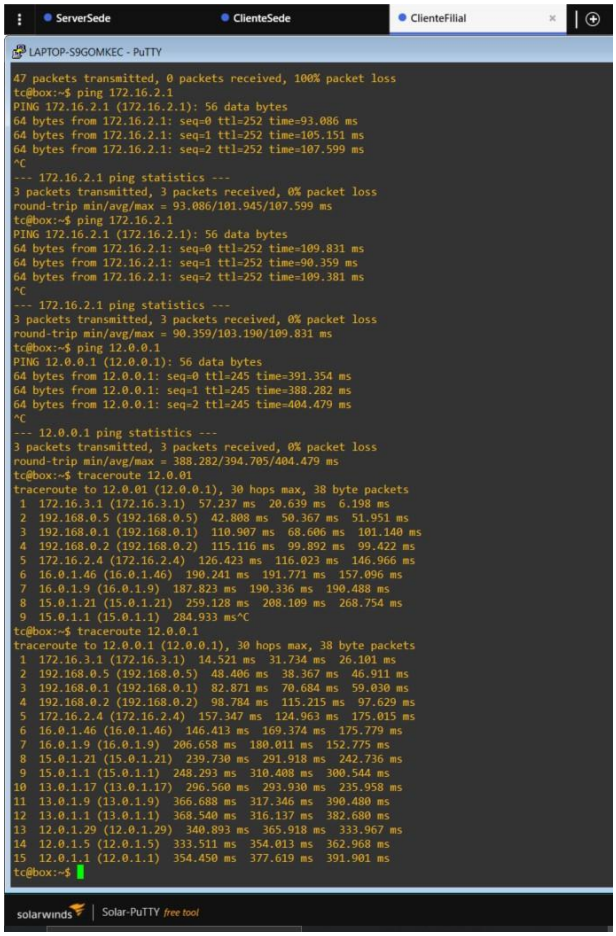


Figura 2- ClienteFilial-Internet (Tier 1 A)

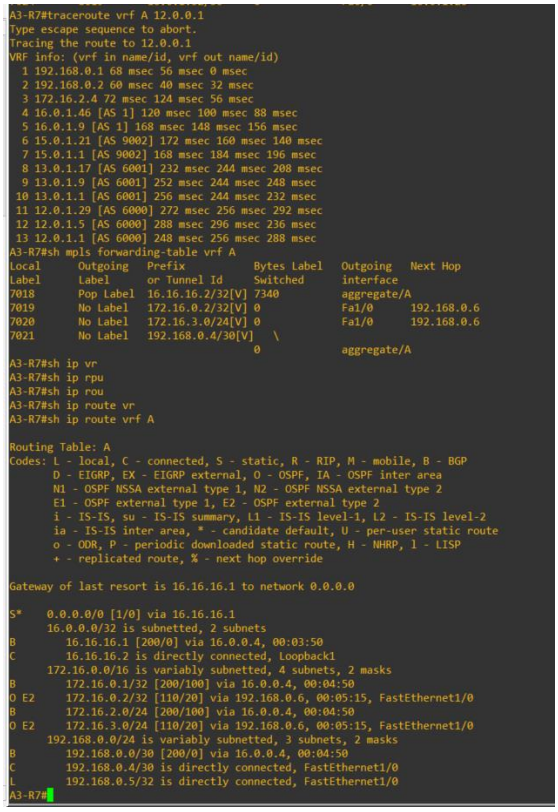


Figura 3- VPN L3 MPLS e visionamento do tráfego escolhido

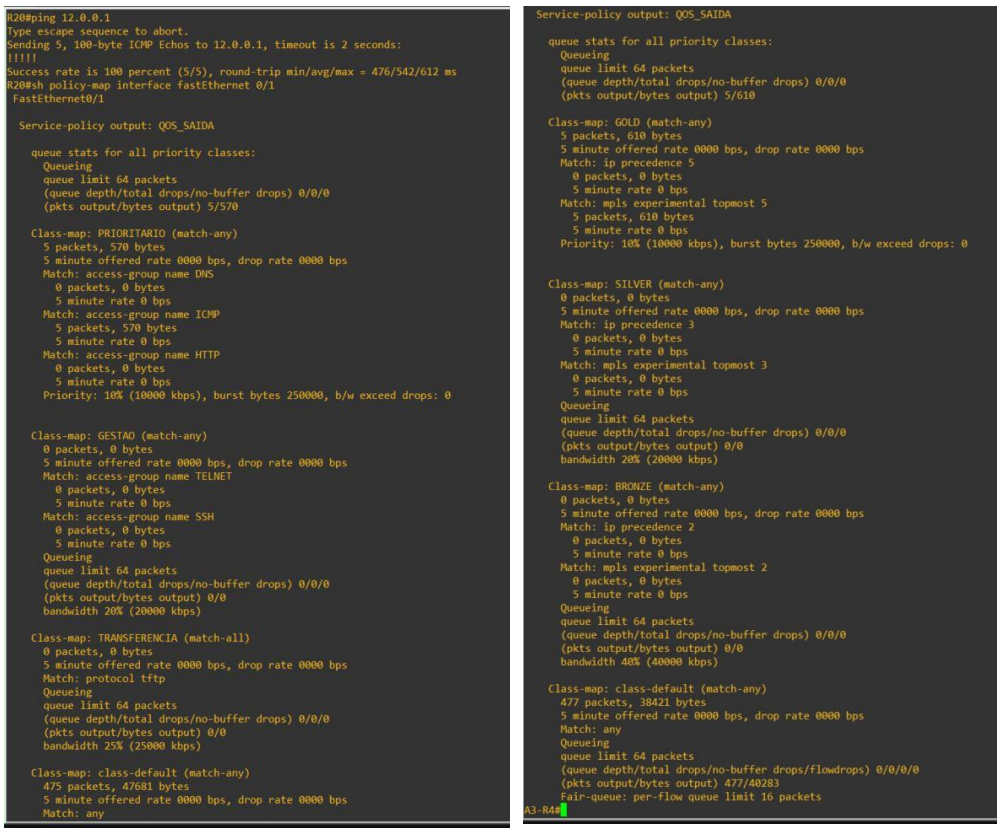
- QOS
- Tier 3 A

```
  2 16.0.1.2 [AS 10001] 136 msec 180 msec 236 msec
B2-R2#ping 16.0.0.2
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 16.0.0.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 136/171/240 ms
B2-R2#
```

```
A3-R1#show policy-map interface gigabitEthernet 5/0
 GigabitEthernet5/0

  Service-policy input: MARCAR

    Class-map: PRIORITARIO (match-any)
      5 packets, 570 bytes
      5 minute offered rate 0000 bps, drop rate 0000 bps
      Match: access-group name DNS
        0 packets, 0 bytes
        5 minute rate 0 bps
      Match: access-group name ICMP
        5 packets, 570 bytes
        5 minute rate 0 bps
      Match: access-group name HTTP
        0 packets, 0 bytes
        5 minute rate 0 bps
      QoS Set
        precedence 5
          Packets marked 5
        mpls experimental topmost 5
          Packets marked 0

    Class-map: GESTAO (match-any)
      0 packets, 0 bytes
      5 minute offered rate 0000 bps, drop rate 0000 bps
      Match: access-group name TELNET
        0 packets, 0 bytes
        5 minute rate 0 bps
      Match: access-group name SSH
        0 packets, 0 bytes
        5 minute rate 0 bps
      QoS Set
        precedence 3
          Packets marked 0
        mpls experimental topmost 3
          Packets marked 0

    Class-map: TRANSFERENCIA (match-all)
      0 packets, 0 bytes
      5 minute offered rate 0000 bps, drop rate 0000 bps
      Match: protocol tftp
      QoS Set
        precedence 2
          Packets marked 0
        mpls experimental topmost 2
          Packets marked 0
```

Figura 4- Qos-MARCAR-TIER 2 A (ping)

- VPN L3 MPLS



```
R20#ping 12.0.0.1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 12.0.0.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 476/542/612 ms
R20#sh policy-map interface fastEthernet 0/1
 FastEthernet0/1

  Service-policy output: QOS_SAIDA

    queue stats for all priority classes:
      Queueing
      queue limit 64 packets
      (queue depth/total drops/no-buffer drops) 0/0/0
      (pkts output/bytes output) 5/570

    Class-map: PRIORITARIO (match-any)
      5 packets, 570 bytes
      5 minute offered rate 0000 bps, drop rate 0000 bps
      Match: access-group name DNS
        0 packets, 0 bytes
        5 minute rate 0 bps
      Match: access-group name ICMP
        5 packets, 570 bytes
        5 minute rate 0 bps
      Match: access-group name HTTP
        0 packets, 0 bytes
        5 minute rate 0 bps
      Priority: 10% (10000 kbps), burst bytes 250000, b/w exceed drops: 0


    Class-map: GESTAO (match-any)
      0 packets, 0 bytes
      5 minute offered rate 0000 bps, drop rate 0000 bps
      Match: access-group name TELNET
        0 packets, 0 bytes
        5 minute rate 0 bps
      Match: access-group name SSH
        0 packets, 0 bytes
        5 minute rate 0 bps
      Queueing
      queue limit 64 packets
      (queue depth/total drops/no-buffer drops) 0/0/0
      (pkts output/bytes output) 0/0
      bandwidth 20% (20000 kbps)

    Class-map: TRANSFERENCIA (match-all)
      0 packets, 0 bytes
      5 minute offered rate 0000 bps, drop rate 0000 bps
      Match: protocol tftp
      Queueing
      queue limit 64 packets
      (queue depth/total drops/no-buffer drops) 0/0/0
      (pkts output/bytes output) 0/0
      bandwidth 25% (25000 kbps)

    Class-map: class-default (match-any)
      475 packets, 47681 bytes
      5 minute offered rate 0000 bps, drop rate 0000 bps
      Match: any
```

```
 Service-policy output: QOS_SAIDA

    queue stats for all priority classes:
      Queueing
      queue limit 64 packets
      (queue depth/total drops/no-buffer drops) 0/0/0
      (pkts output/bytes output) 5/610

    Class-map: GOLD (match-any)
      5 packets, 610 bytes
      5 minute offered rate 0000 bps, drop rate 0000 bps
      Match: ip precedence 5
        0 packets, 0 bytes
        5 minute rate 0 bps
      Match: mpls experimental topmost 5
        5 packets, 610 bytes
        5 minute rate 0 bps
      Priority: 10% (10000 kbps), burst bytes 250000, b/w exceed drops: 0


    Class-map: SILVER (match-any)
      0 packets, 0 bytes
      5 minute offered rate 0000 bps, drop rate 0000 bps
      Match: ip precedence 3
        0 packets, 0 bytes
        5 minute rate 0 bps
      Match: mpls experimental topmost 3
        0 packets, 0 bytes
        5 minute rate 0 bps
      Queueing
      queue limit 64 packets
      (queue depth/total drops/no-buffer drops) 0/0/0
      (pkts output/bytes output) 0/0
      bandwidth 20% (20000 kbps)

    Class-map: BRONZE (match-any)
      0 packets, 0 bytes
      5 minute offered rate 0000 bps, drop rate 0000 bps
      Match: ip precedence 2
        0 packets, 0 bytes
        5 minute rate 0 bps
      Match: mpls experimental topmost 2
        0 packets, 0 bytes
        5 minute rate 0 bps
      Queueing
      queue limit 64 packets
      (queue depth/total drops/no-buffer drops) 0/0/0
      (pkts output/bytes output) 0/0
      bandwidth 40% (40000 kbps)

    Class-map: class-default (match-any)
      477 packets, 38421 bytes
      5 minute offered rate 0000 bps, drop rate 0000 bps
      Match: any
      Queueing
      queue limit 64 packets
      (queue depth/total drops/no-buffer drops/flowdrops) 0/0/0/0
      (pkts output/bytes output) 477/40283
      Fair-queue: per-flow queue limit 16 packets
A3-R4#
```

Figura 5- QOS na VPN entre os routers do Tier 3 A (ping)

```
R19#telnet 16.16.16.1
Trying 16.16.16.1 ... Open


Password required, but none set

[Connection to 16.16.16.1 closed by foreign host]
R19#show policy-map interface 2/1
                              ^
% Invalid input detected at '^' marker.

R19#show policy-map interface f2/1
R19#show policy-map interface fad
R19#show policy-map interface fas
R19#show policy-map interface fastEthernet 2/1
R19#show policy-map interface fastEthernet 0/1
 FastEthernet0/1

  Service-policy output: QOS_SAIDA

    queue stats for all priority classes:
      Queueing
      queue limit 64 packets
      (queue depth/total drops/no-buffer drops) 0/0/0
      (pkts output/bytes output) 5/570

    Class-map: PRIORITARIO (match-any)
      5 packets, 570 bytes
      5 minute offered rate 0000 bps, drop rate 0000 bps
      Match: access-group name DNS
        0 packets, 0 bytes
        5 minute rate 0 bps
      Match: access-group name ICMP
        5 packets, 570 bytes
        5 minute rate 0 bps
      Match: access-group name HTTP
        0 packets, 0 bytes
        5 minute rate 0 bps
      Priority: 10% (10000 kbps), burst bytes 250000, b/w exceed drops: 0


    Class-map: GESTAO (match-any)
      10 packets, 606 bytes
      5 minute offered rate 0000 bps, drop rate 0000 bps
      Match: access-group name TELNET
        10 packets, 606 bytes
        5 minute rate 0 bps
      Match: access-group name SSH
        0 packets, 0 bytes
        5 minute rate 0 bps
      Queueing
      queue limit 64 packets
      (queue depth/total drops/no-buffer drops) 0/0/0
      (pkts output/bytes output) 10/606
      bandwidth 20% (20000 kbps)

    Class-map: TRANSFERENCIA (match-all)
      0 packets, 0 bytes
      5 minute offered rate 0000 bps, drop rate 0000 bps
      Match: protocol tftp
```

Figura 6- Qos pacote telnet identificado na saída R19

- ➢ BGP E IGP

- Tier 1 A

```
A1-R1#sh bgp
BGP table version is 11, local router ID is 6.6.6.6
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal,
              r RIB-failure, S Stale, m multipath, b backup-path, f RT-Filter,
              x best-external, a additional-path, c RIB-compressed,
Origin codes: i - IGP, e - EGP, ? - incomplete
RPKI validation codes: V valid, I invalid, N Not found

     Network          Next Hop            Metric LocPrf Weight Path
 * i 12.0.0.0/16      12.0.0.3                 0    100      0 ?
 *>                   0.0.0.0                  0         32768 ?
 *>i 13.0.0.0/16      12.0.0.3                 0    140      0 6001 ?
 *m  14.0.0.0/16      12.0.1.22                0    120      0 9001 ?
 *>                   12.0.1.18                0    120      0 9001 ?
 *m  15.0.0.0/16      12.0.1.22                     120      0 9001 10001 9002 ?
 *>                   12.0.1.18                     120      0 9001 10001 9002 ?
 *m  16.0.0.0/16      12.0.1.22                     120      0 9001 10001 ?
 *>                   12.0.1.18                     120      0 9001 10001 ?
A1-R1#sh bgp ipv
A1-R1#sh bgp ipv6
BGP table version is 10, local router ID is 6.6.6.6
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal,
              r RIB-failure, S Stale, m multipath, b backup-path, f RT-Filter,
              x best-external, a additional-path, c RIB-compressed,
Origin codes: i - IGP, e - EGP, ? - incomplete
RPKI validation codes: V valid, I invalid, N Not found

     Network          Next Hop            Metric LocPrf Weight Path
 * i 2222:2397:1::/48 2222:2397:1::3           0    100      0 ?
 *>                   ::                       0         32768 ?
 *>i 2222:2397:2::/48 2222:2397:1::3           0    140      0 6001 ?
 *>  2222:2397:3::/48 2222:2397:1:5::2
                                              0    120      0 9001 ?
 *m                   2222:2397:1:6::2
                                              0    120      0 9001 ?
 *m  2222:2397:4::/48 2222:2397:1:6::2
                                                   120      0 9001 10001 9002 ?
 *>                   2222:2397:1:5::2
                                                   120      0 9001 10001 9002 ?
 *m  2222:2397:5::/48 2222:2397:1:6::2
                                                   120      0 9001 10001 ?
     Network          Next Hop            Metric LocPrf Weight Path
 *>                   2222:2397:1:5::2
                                                   120      0 9001 10001 ?
% NOTE: This command is deprecated. Please use 'show bgp ipv6 unicast'
A1-R1#
```

Figura 7- Tier 1 A escolha das rotas BGP

```
A1-R3#sh ipv6 route
IPv6 Routing Table - default - 19 entries
Codes: C - Connected, L - Local, S - Static, U - Per-user Static route
       B - BGP, HA - Home Agent, MR - Mobile Router, R - RIP
       H - NHRP, I1 - ISIS L1, I2 - ISIS L2, IA - ISIS interarea
       IS - ISIS summary, D - EIGRP, EX - EIGRP external, NM - NEMO
       ND - ND Default, NDp - ND Prefix, DCE - Destination, NDr - Redirect
       O - OSPF Intra, OI - OSPF Inter, OE1 - OSPF ext 1, OE2 - OSPF ext 2
       ON1 - OSPF NSSA ext 1, ON2 - OSPF NSSA ext 2, l - LISP
S   2222:2397:1::/48 [1/0]
     via Null0, directly connected
O   2222:2397:1::1/128 [110/2]
     via FE80::6000:2, FastEthernet0/1
O   2222:2397:1::2/128 [110/1]
     via FE80::6000:2, FastEthernet0/1
LC  2222:2397:1::3/128 [0/0]
     via Loopback0, receive
O   2222:2397:1::4/128 [110/2]
     via FE80::6000:2, FastEthernet0/1
O   2222:2397:1:1::/64 [110/2]
     via FE80::6000:2, FastEthernet0/1
C   2222:2397:1:2::/64 [0/0]
     via FastEthernet0/1, directly connected
L   2222:2397:1:2::2/128 [0/0]
     via FastEthernet0/1, receive
O   2222:2397:1:3::/64 [110/2]
     via FE80::6000:2, FastEthernet0/1
O   2222:2397:1:4::/64 [110/3]
     via FE80::6000:2, FastEthernet0/1
C   2222:2397:1:7::/64 [0/0]
     via GigabitEthernet3/0, directly connected
L   2222:2397:1:7::1/128 [0/0]
     via GigabitEthernet3/0, receive
C   2222:2397:1:8::/64 [0/0]
     via GigabitEthernet4/0, directly connected
L   2222:2397:1:8::1/128 [0/0]
     via GigabitEthernet4/0, receive
B   2222:2397:2::/48 [20/0]
     via FE80::6001:1, GigabitEthernet3/0
     via FE80::6001:1, GigabitEthernet4/0
B   2222:2397:3::/48 [200/0]
     via 2222:2397:1::1
B   2222:2397:4::/48 [200/0]
     via 2222:2397:1::1
B   2222:2397:5::/48 [200/0]
     via 2222:2397:1::1
L   FF00::/8 [0/0]
     via Null0, receive
A1-R3#
```

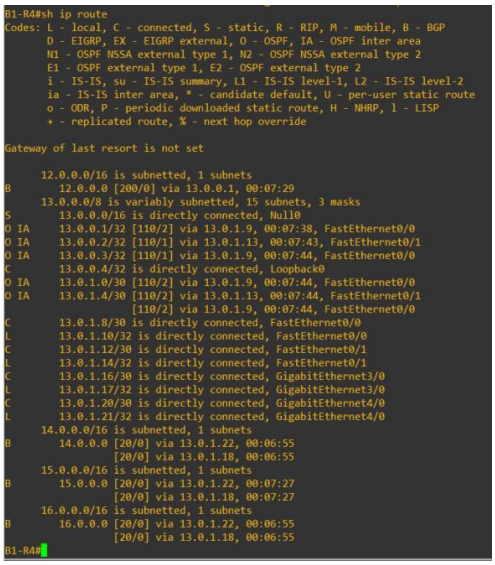
```
A1-R3#sh ip route
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       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

     12.0.0.0/8 is variably subnetted, 14 subnets, 3 masks
S       12.0.0.0/16 is directly connected, Null0
O       12.0.0.1/32 [110/2] via 12.0.1.5, 00:08:10, FastEthernet0/1
O       12.0.0.2/32 [110/1] via 12.0.1.5, 00:08:10, FastEthernet0/1
C       12.0.0.3/32 is directly connected, Loopback0
O       12.0.0.4/32 [110/2] via 12.0.1.5, 00:08:10, FastEthernet0/1
O       12.0.1.0/30 [110/2] via 12.0.1.5, 00:08:10, FastEthernet0/1
C       12.0.1.4/30 is directly connected, FastEthernet0/1
L       12.0.1.6/32 is directly connected, FastEthernet0/1
O       12.0.1.8/30 [110/2] via 12.0.1.5, 00:08:10, FastEthernet0/1
O       12.0.1.12/30 [110/3] via 12.0.1.5, 00:08:10, FastEthernet0/1
C       12.0.1.24/30 is directly connected, GigabitEthernet3/0
L       12.0.1.25/32 is directly connected, GigabitEthernet3/0
C       12.0.1.28/30 is directly connected, GigabitEthernet4/0
L       12.0.1.29/32 is directly connected, GigabitEthernet4/0
     13.0.0.0/16 is subnetted, 1 subnets
B       13.0.0.0 [20/0] via 12.0.1.30, 00:08:06
                 [20/0] via 12.0.1.26, 00:08:06
     14.0.0.0/16 is subnetted, 1 subnets
B       14.0.0.0 [200/0] via 12.0.0.1, 00:08:01
     15.0.0.0/16 is subnetted, 1 subnets
B       15.0.0.0 [200/0] via 12.0.0.1, 00:07:36
     16.0.0.0/16 is subnetted, 1 subnets
B       16.0.0.0 [200/0] via 12.0.0.1, 00:07:36
A1-R3#
```

Figura 8- Rotas

- Tier 1 B

```
B1-R2#sh bgp ipv6 unicast
BGP table version is 15, local router ID is 2.2.2.2
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal,
              r RIB-failure, S Stale, m multipath, b backup-path, f RT-Filter,
              x best-external, a additional-path, c RIB-compressed,
Origin codes: i - IGP, e - EGP, ? - incomplete
RPKI validation codes: V valid, I invalid, N Not found

     Network          Next Hop            Metric LocPrf Weight Path
 *   2222:2397:1::/48 2222:2397:2:7::2                         0 9001 6000 ?
 *>i                  2222:2397:2::1          0    140      0 6000 ?
 *                    2222:2397:1:9::1                       0    130      0 6000 ?
 *                    2222:2397:1:A::1                       0    130      0 6000 ?
 * i 2222:2397:2::/48 2222:2397:2::1          0    100      0 ?
 *>                   ::                      0         32768 ?
 *>i 2222:2397:3::/48 2222:2397:2::4          0    120      0 9002 6000 9001 ?
 *                    2222:2397:2:7::2                       0             0 9001 ?
 *>i 2222:2397:4::/48 2222:2397:2::4          0    120      0 9002 ?
 *>i 2222:2397:5::/48 2222:2397:2::4          0    120      0 9002 10001 ?
 *                    2222:2397:2:7::2
     Network          Next Hop            Metric LocPrf Weight Path
                                                             0 9001 10001 ?
B1-R2#sh bgp
BGP table version is 15, local router ID is 2.2.2.2
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal,
              r RIB-failure, S Stale, m multipath, b backup-path, f RT-Filter,
              x best-external, a additional-path, c RIB-compressed,
Origin codes: i - IGP, e - EGP, ? - incomplete
RPKI validation codes: V valid, I invalid, N Not found

     Network          Next Hop            Metric LocPrf Weight Path
 *   12.0.0.0/16      13.0.1.26                              0 9001 6000 ?
 *>i                  13.0.0.1                 0    140      0 6000 ?
 *                    12.0.1.33                0    130      0 6000 ?
 *                    12.0.1.37                0    130      0 6000 ?
 * i 13.0.0.0/16      13.0.0.1                 0    100      0 ?
 *>                   0.0.0.0                  0         32768 ?
 *>i 14.0.0.0/16      13.0.0.4                 0    120      0 9002 6000 9001 ?
 *                    13.0.1.26                0             0 9001 ?
 *>i 15.0.0.0/16      13.0.0.4                 0    120      0 9002 ?
 *>i 16.0.0.0/16      13.0.0.4                 0    120      0 9002 10001 ?
 *                    13.0.1.26                              0 9001 10001 ?
B1-R2#
```

Figura 9- Tier 1 B escolha das rotas BGP



```
B1-R4#sh 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

      12.0.0.0/16 is subnetted, 1 subnets
B        12.0.0.0 [200/0] via 13.0.0.1, 00:07:29
      13.0.0.0/8 is variably subnetted, 15 subnets, 3 masks
S        13.0.0.0/16 is directly connected, Null0
O IA     13.0.0.1/32 [110/2] via 13.0.1.9, 00:07:38, FastEthernet0/0
O IA     13.0.0.2/32 [110/1] via 13.0.1.13, 00:07:43, FastEthernet0/1
O IA     13.0.0.3/32 [110/1] via 13.0.1.9, 00:07:44, FastEthernet0/0
C        13.0.0.4/32 is directly connected, Loopback0
O IA     13.0.1.0/30 [110/2] via 13.0.1.9, 00:07:44, FastEthernet0/0
O IA     13.0.1.4/30 [110/2] via 13.0.1.13, 00:07:44, FastEthernet0/1
                     [110/2] via 13.0.1.9, 00:07:44, FastEthernet0/0
C        13.0.1.8/30 is directly connected, FastEthernet0/0
L        13.0.1.10/32 is directly connected, FastEthernet0/0
C        13.0.1.12/30 is directly connected, FastEthernet0/1
L        13.0.1.14/32 is directly connected, FastEthernet0/1
C        13.0.1.16/30 is directly connected, GigabitEthernet3/0
L        13.0.1.17/32 is directly connected, GigabitEthernet3/0
C        13.0.1.20/30 is directly connected, GigabitEthernet4/0
L        13.0.1.21/32 is directly connected, GigabitEthernet4/0
      14.0.0.0/16 is subnetted, 1 subnets
B        14.0.0.0 [20/0] via 13.0.1.22, 00:06:55
                  [20/0] via 13.0.1.18, 00:06:55
      15.0.0.0/16 is subnetted, 1 subnets
B        15.0.0.0 [20/0] via 13.0.1.22, 00:07:27
                  [20/0] via 13.0.1.18, 00:07:27
      16.0.0.0/16 is subnetted, 1 subnets
B        16.0.0.0 [20/0] via 13.0.1.22, 00:06:55
                  [20/0] via 13.0.1.18, 00:06:55
B1-R4#
```

```
B1-R4#sh ipv6 route
IPv6 Routing Table - default - 20 entries
Codes: C - Connected, L - Local, S - Static, U - Per-user Static route
       B - BGP, HA - Home Agent, MR - Mobile Router, R - RIP
       H - NHRP, I1 - ISIS L1, I2 - ISIS L2, IA - ISIS interarea
       IS - ISIS summary, D - EIGRP, EX - EIGRP external, NM - NEMO
       ND - ND Default, NDp - ND Prefix, DCE - Destination, NDr - Redirect
       O - OSPF Intra, OI - OSPF Inter, OE1 - OSPF ext 1, OE2 - OSPF ext 2
       ON1 - OSPF NSSA ext 1, ON2 - OSPF NSSA ext 2, l - LISP
B   2222:2397:1::/48 [200/0]
     via 2222:2397:2::1
S   2222:2397:2::/48 [1/0]
     via Null0, directly connected
OI  2222:2397:2::1/128 [110/2]
     via FE80::6001:3, FastEthernet0/0
OI  2222:2397:2::2/128 [110/1]
     via FE80::6001:2, FastEthernet0/1
OI  2222:2397:2::3/128 [110/1]
     via FE80::6001:3, FastEthernet0/0
LC  2222:2397:2::4/128 [0/0]
     via Loopback0, receive
OI  2222:2397:2:1::/64 [110/2]
     via FE80::6001:3, FastEthernet0/0
OI  2222:2397:2:2::/64 [110/2]
     via FE80::6001:2, FastEthernet0/1
     via FE80::6001:3, FastEthernet0/0
C   2222:2397:2:3::/64 [0/0]
     via FastEthernet0/0, directly connected
L   2222:2397:2:3::2/128 [0/0]
     via FastEthernet0/0, receive
C   2222:2397:2:4::/64 [0/0]
     via FastEthernet0/1, directly connected
L   2222:2397:2:4::2/128 [0/0]
     via FastEthernet0/1, receive
C   2222:2397:2:5::/64 [0/0]
     via GigabitEthernet3/0, directly connected
L   2222:2397:2:5::1/128 [0/0]
     via GigabitEthernet3/0, receive
C   2222:2397:2:6::/64 [0/0]
     via GigabitEthernet4/0, directly connected
L   2222:2397:2:6::1/128 [0/0]
     via GigabitEthernet4/0, receive
B   2222:2397:3::/48 [20/0]
     via FE80::9002:1, GigabitEthernet4/0
     via FE80::9002:1, GigabitEthernet3/0
B   2222:2397:4::/48 [20/0]
     via FE80::9002:1, GigabitEthernet4/0
     via FE80::9002:1, GigabitEthernet3/0
B   2222:2397:5::/48 [20/0]
     via FE80::9002:1, GigabitEthernet4/0
     via FE80::9002:1, GigabitEthernet3/0
L   FF00::/8 [0/0]
     via Null0, receive
B1-R4#
```

Figura 10- Rotas

- Tier 2 A

```
A2-R2#sh bgp
BGP table version is 14, local router ID is 2.2.2.2
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal,
              r RIB-failure, S Stale, m multipath, b backup-path, f RT-Filter,
              x best-external, a additional-path, c RIB-compressed,
Origin codes: i - IGP, e - EGP, ? - incomplete
RPKI validation codes: V valid, I invalid, N Not found

     Network          Next Hop            Metric LocPrf Weight Path
 *>i 12.0.0.0/16      14.0.0.1                 0    120      0 6000 ?
 *>i 13.0.0.0/16      14.0.0.1                 0    120      0 6000 6001 ?
 * i 14.0.0.0/16      14.0.0.4                 0    100      0 ?
 * i                  14.0.0.3                 0    100      0 ?
 *>i                  14.0.0.1                 0    100      0 ?
 *>i 15.0.0.0/16      14.0.0.4                 0    100      0 10001 9002 ?
 * i                  14.0.0.3                 0    100      0 6001 9002 ?
 *>i 16.0.0.0/16      14.0.0.4                 0    100      0 10001 ?
 * i                  14.0.0.3                 0    100      0 10001 ?
A2-R2#sh bg
A2-R2#sh bgp ipv
A2-R2#sh bgp ipv6 unic
A2-R2#sh bgp ipv6 unicast
BGP table version is 14, local router ID is 2.2.2.2
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal,
              r RIB-failure, S Stale, m multipath, b backup-path, f RT-Filter,
              x best-external, a additional-path, c RIB-compressed,
Origin codes: i - IGP, e - EGP, ? - incomplete
RPKI validation codes: V valid, I invalid, N Not found

     Network          Next Hop            Metric LocPrf Weight Path
 *>i 2222:2397:1::/48 2222:2397:3::1           0    120      0 6000 ?
 *>i 2222:2397:2::/48 2222:2397:3::1           0    120      0 6000 6001 ?
 * i 2222:2397:3::/48 2222:2397:3::4           0    100      0 ?
 * i                  2222:2397:3::3           0    100      0 ?
 *>i                  2222:2397:3::1           0    100      0 ?
 *>i 2222:2397:4::/48 2222:2397:3::4           0    100      0 10001 9002 ?
 * i                  2222:2397:3::3           0    100      0 6001 9002 ?
 *>i 2222:2397:5::/48 2222:2397:3::4           0    100      0 10001 ?
 * i                  2222:2397:3::3           0    100      0 10001 ?
A2-R2#
```

Figura 11- Tier 2 A escolha das rotas BGP

```
A2-R2#sh 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

      12.0.0.0/16 is subnetted, 1 subnets
B        12.0.0.0 [200/0] via 14.0.0.1, 00:09:09
      13.0.0.0/16 is subnetted, 1 subnets
B        13.0.0.0 [200/0] via 14.0.0.1, 00:08:42
      14.0.0.0/8 is variably subnetted, 13 subnets, 3 masks
B        14.0.0.0/16 [200/0] via 14.0.0.1, 00:09:09
O        14.0.0.1/32 [110/1] via 14.0.1.1, 00:09:15, FastEthernet0/1
C        14.0.0.2/32 is directly connected, Loopback0
O        14.0.0.3/32 [110/1] via 14.0.1.14, 00:09:15, FastEthernet0/0
O        14.0.0.4/32 [110/1] via 14.0.1.18, 00:09:15, FastEthernet1/0
C        14.0.1.0/30 is directly connected, FastEthernet0/1
L        14.0.1.2/32 is directly connected, FastEthernet0/1
O        14.0.1.4/30 [110/2] via 14.0.1.14, 00:09:15, FastEthernet0/0
                     [110/2] via 14.0.1.1, 00:09:15, FastEthernet0/1
O        14.0.1.8/30 [110/2] via 14.0.1.18, 00:09:15, FastEthernet1/0
                     [110/2] via 14.0.1.1, 00:09:15, FastEthernet0/1
C        14.0.1.12/30 is directly connected, FastEthernet0/0
L        14.0.1.13/32 is directly connected, FastEthernet0/0
C        14.0.1.16/30 is directly connected, FastEthernet1/0
L        14.0.1.17/32 is directly connected, FastEthernet1/0
      15.0.0.0/16 is subnetted, 1 subnets
B        15.0.0.0 [200/0] via 14.0.0.4, 00:01:10
      16.0.0.0/16 is subnetted, 1 subnets
B        16.0.0.0 [200/0] via 14.0.0.4, 00:01:10
A2-R2#
```

```
A2-R2#sh ipv6 route
IPv6 Routing Table - default - 18 entries
Codes: C - Connected, L - Local, S - Static, U - Per-user Static route
       B - BGP, HA - Home Agent, MR - Mobile Router, R - RIP
       H - NHRP, I1 - ISIS L1, I2 - ISIS L2, IA - ISIS interarea
       IS - ISIS summary, D - EIGRP, EX - EIGRP external, NM - NEMO
       ND - ND Default, NDp - ND Prefix, DCE - Destination, NDr - Redirect
       O - OSPF Intra, OI - OSPF Inter, OE1 - OSPF ext 1, OE2 - OSPF ext 2
       ON1 - OSPF NSSA ext 1, ON2 - OSPF NSSA ext 2, l - LISP
B   2222:2397:1::/48 [200/0]
     via 2222:2397:3::1
B   2222:2397:2::/48 [200/0]
     via 2222:2397:3::1
B   2222:2397:3::/48 [200/0]
     via 2222:2397:3::1
O   2222:2397:3::1/128 [110/1]
     via FE80::9001:1, FastEthernet0/1
LC  2222:2397:3::2/128 [0/0]
     via Loopback0, receive
O   2222:2397:3::3/128 [110/1]
     via FE80::9001:3, FastEthernet0/0
O   2222:2397:3::4/128 [110/1]
     via FE80::9001:4, FastEthernet1/0
C   2222:2397:3:1::/64 [0/0]
     via FastEthernet0/1, directly connected
L   2222:2397:3:1::2/128 [0/0]
     via FastEthernet0/1, receive
O   2222:2397:3:2::/64 [110/2]
     via FE80::9001:1, FastEthernet0/1
     via FE80::9001:3, FastEthernet0/0
O   2222:2397:3:3::/64 [110/2]
     via FE80::9001:1, FastEthernet0/1
     via FE80::9001:4, FastEthernet1/0
C   2222:2397:3:4::/64 [0/0]
     via FastEthernet0/0, directly connected
L   2222:2397:3:4::1/128 [0/0]
     via FastEthernet0/0, receive
C   2222:2397:3:5::/64 [0/0]
     via FastEthernet1/0, directly connected
L   2222:2397:3:5::1/128 [0/0]
     via FastEthernet1/0, receive
B   2222:2397:4::/48 [200/0]
     via 2222:2397:3::4
B   2222:2397:5::/48 [200/0]
     via 2222:2397:3::4
L   FF00::/8 [0/0]
     via Null0, receive
A2-R2#
```

Figura 12- Rotas

- Tier 2 B

```
B2-R3#sh bgp
BGP table version is 7, local router ID is 3.3.3.3
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal,
              r RIB-failure, S Stale, m multipath, b backup-path, f RT-Filter,
              x best-external, a additional-path, c RIB-compressed,
Origin codes: i - IGP, e - EGP, ? - incomplete
RPKI validation codes: V valid, I invalid, N Not found

     Network          Next Hop            Metric LocPrf Weight Path
 *>i 12.0.0.0/16      15.0.0.1                 0    120      0 6001 6000 ?
 *>i 13.0.0.0/16      15.0.0.1                 0    120      0 6001 ?
 *>i 14.0.0.0/16      15.0.0.2                 0    100      0 10001 9001 ?
 r i 15.0.0.0/16      15.0.0.2                 0    100      0 ?
 r>i                  15.0.0.1                 0    100      0 ?
 *>i 16.0.0.0/16      15.0.0.2                 0    100      0 10001 ?
B2-R3#sh bgp ipv6
BGP table version is 8, local router ID is 3.3.3.3
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal,
              r RIB-failure, S Stale, m multipath, b backup-path, f RT-Filter,
              x best-external, a additional-path, c RIB-compressed,
Origin codes: i - IGP, e - EGP, ? - incomplete
RPKI validation codes: V valid, I invalid, N Not found

     Network          Next Hop            Metric LocPrf Weight Path
 *>i 2222:2397:1::/48 2222:2397:4::1           0    120      0 6001 6000 ?
 *>i 2222:2397:2::/48 2222:2397:4::1           0    120      0 6001 ?
 *>i 2222:2397:3::/48 2222:2397:4::2           0    100      0 10001 9001 ?
 * i 2222:2397:4::/48 2222:2397:4::2           0    100      0 ?
 *>i                  2222:2397:4::1           0    100      0 ?
 *>i 2222:2397:5::/48 2222:2397:4::2           0    100      0 10001 ?
% NOTE: This command is deprecated. Please use 'show bgp ipv6 unicast'
B2-R3#
```

Figura 13-Tier 2 B preferências rotas BGP

```
B2-R3#sh ipv6 route
IPv6 Routing Table - default - 16 entries
Codes: C - Connected, L - Local, S - Static, U - Per-user Static route
       B - BGP, HA - Home Agent, MR - Mobile Router, R - RIP
       H - NHRP, I1 - ISIS L1, I2 - ISIS L2, IA - ISIS interarea
       IS - ISIS summary, D - EIGRP, EX - EIGRP external, NM - NEMO
       ND - ND Default, NDp - ND Prefix, DCE - Destination, NDr - Redirect
       O - OSPF Intra, OI - OSPF Inter, OE1 - OSPF ext 1, OE2 - OSPF ext 2
       ON1 - OSPF NSSA ext 1, ON2 - OSPF NSSA ext 2, l - LISP
B   2222:2397:1::/48 [200/0]
     via 2222:2397:4::1
B   2222:2397:2::/48 [200/0]
     via 2222:2397:4::1
B   2222:2397:3::/48 [200/0]
     via 2222:2397:4::2
B   2222:2397:4::/48 [200/0]
     via 2222:2397:4::1
R   2222:2397:4::1/128 [120/2]
     via FE80::9002:1, FastEthernet0/1
R   2222:2397:4::2/128 [120/2]
     via FE80::9002:2, FastEthernet1/0
LC  2222:2397:4::3/128 [0/0]
     via Loopback0, receive
R   2222:2397:4:1::/64 [120/2]
     via FE80::9002:1, FastEthernet0/1
     via FE80::9002:2, FastEthernet1/0
C   2222:2397:4:2::/64 [0/0]
     via FastEthernet0/1, directly connected
L   2222:2397:4:2::2/128 [0/0]
     via FastEthernet0/1, receive
C   2222:2397:4:3::/64 [0/0]
     via FastEthernet1/0, directly connected
L   2222:2397:4:3::2/128 [0/0]
     via FastEthernet1/0, receive
C   2222:2397:4:7::/64 [0/0]
     via FastEthernet0/0, directly connected
L   2222:2397:4:7::1/128 [0/0]
     via FastEthernet0/0, receive
B   2222:2397:5::/48 [200/0]
     via 2222:2397:4::2
L   FF00::/8 [0/0]
     via Null0, receive
B2-R3#
```

```
B2-R3#sh 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

      12.0.0.0/16 is subnetted, 1 subnets
B        12.0.0.0 [200/0] via 15.0.0.1, 00:27:01
      13.0.0.0/16 is subnetted, 1 subnets
B        13.0.0.0 [200/0] via 15.0.0.1, 00:28:07
      14.0.0.0/16 is subnetted, 1 subnets
B        14.0.0.0 [200/0] via 15.0.0.2, 00:28:07
      15.0.0.0/8 is variably subnetted, 14 subnets, 4 masks
R        15.0.0.0/16 [120/1] via 15.0.1.9, 00:01:03, FastEthernet1/0
                     [120/1] via 15.0.1.5, 00:00:05, FastEthernet0/1
R        15.0.0.1/32 [120/1] via 15.0.1.5, 00:00:05, FastEthernet0/1
R        15.0.0.2/32 [120/1] via 15.0.1.9, 00:01:04, FastEthernet1/0
C        15.0.0.3/32 is directly connected, Loopback0
R        15.0.1.0/30 [120/1] via 15.0.1.9, 00:01:04, FastEthernet1/0
                     [120/1] via 15.0.1.5, 00:00:05, FastEthernet0/1
C        15.0.1.4/30 is directly connected, FastEthernet0/1
L        15.0.1.6/32 is directly connected, FastEthernet0/1
C        15.0.1.8/30 is directly connected, FastEthernet1/0
L        15.0.1.10/32 is directly connected, FastEthernet1/0
R        15.0.1.12/30 [120/1] via 15.0.1.9, 00:01:04, FastEthernet1/0
R        15.0.1.16/30 [120/1] via 15.0.1.9, 00:01:04, FastEthernet1/0
R        15.0.1.20/30 [120/1] via 15.0.1.9, 00:01:04, FastEthernet1/0
C        15.0.2.0/24 is directly connected, FastEthernet0/0
L        15.0.2.1/32 is directly connected, FastEthernet0/0
      16.0.0.0/16 is subnetted, 1 subnets
B        16.0.0.0 [200/0] via 15.0.0.2, 00:28:08
B2-R3#
```

Figura 14- Rotas

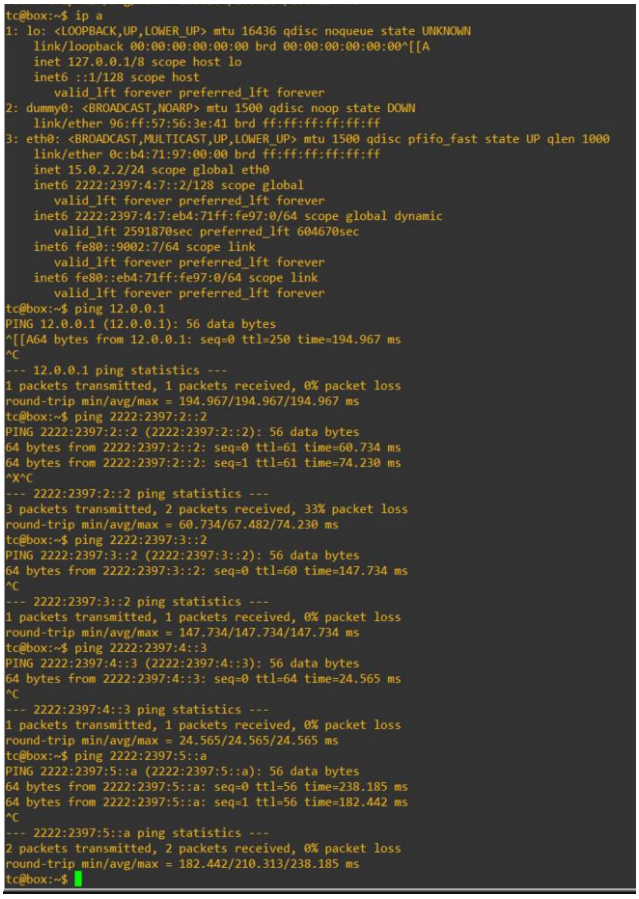
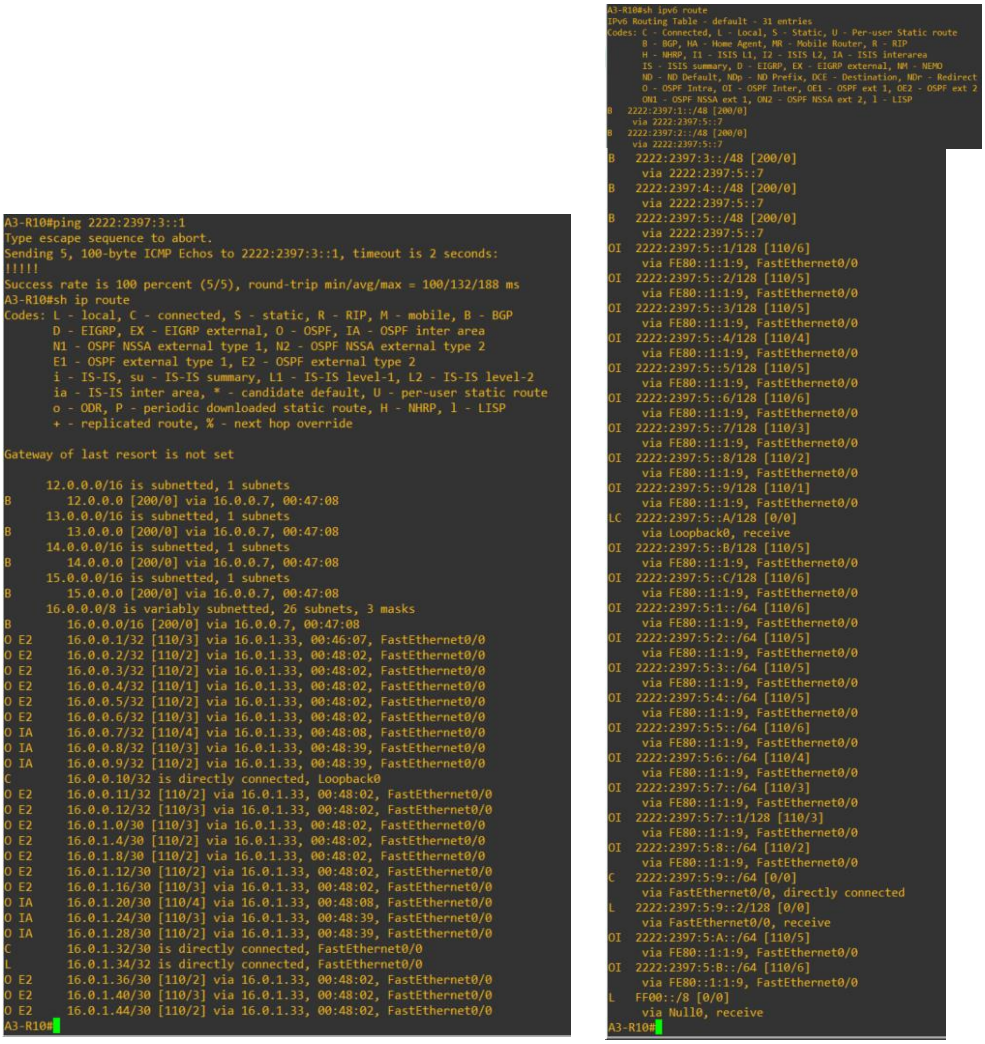


Figura 15- ServerAS9002 Pings para diversos Tiers

- Tier 3 A



```
A3-R10#ping 2222:2397:3::1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 2222:2397:3::1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 100/132/188 ms
A3-R10#sh 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

      12.0.0.0/16 is subnetted, 1 subnets
B        12.0.0.0 [200/0] via 16.0.0.7, 00:47:08
      13.0.0.0/16 is subnetted, 1 subnets
B        13.0.0.0 [200/0] via 16.0.0.7, 00:47:08
      14.0.0.0/16 is subnetted, 1 subnets
B        14.0.0.0 [200/0] via 16.0.0.7, 00:47:08
      15.0.0.0/16 is subnetted, 1 subnets
B        15.0.0.0 [200/0] via 16.0.0.7, 00:47:08
      16.0.0.0/8 is variably subnetted, 26 subnets, 3 masks
B        16.0.0.0/16 [200/0] via 16.0.0.7, 00:47:08
O E2     16.0.0.1/32 [110/3] via 16.0.1.33, 00:46:07, FastEthernet0/0
O E2     16.0.0.2/32 [110/2] via 16.0.1.33, 00:48:02, FastEthernet0/0
O E2     16.0.0.3/32 [110/2] via 16.0.1.33, 00:48:02, FastEthernet0/0
O E2     16.0.0.4/32 [110/1] via 16.0.1.33, 00:48:02, FastEthernet0/0
O E2     16.0.0.5/32 [110/2] via 16.0.1.33, 00:48:02, FastEthernet0/0
O E2     16.0.0.6/32 [110/3] via 16.0.1.33, 00:48:02, FastEthernet0/0
O IA     16.0.0.7/32 [110/4] via 16.0.1.33, 00:48:08, FastEthernet0/0
O IA     16.0.0.8/32 [110/3] via 16.0.1.33, 00:48:39, FastEthernet0/0
O IA     16.0.0.9/32 [110/2] via 16.0.1.33, 00:48:39, FastEthernet0/0
C        16.0.0.10/32 is directly connected, Loopback0
O E2     16.0.0.11/32 [110/2] via 16.0.1.33, 00:48:02, FastEthernet0/0
O E2     16.0.0.12/32 [110/3] via 16.0.1.33, 00:48:02, FastEthernet0/0
O E2     16.0.1.0/30 [110/3] via 16.0.1.33, 00:48:02, FastEthernet0/0
O E2     16.0.1.4/30 [110/2] via 16.0.1.33, 00:48:02, FastEthernet0/0
O E2     16.0.1.8/30 [110/2] via 16.0.1.33, 00:48:02, FastEthernet0/0
O E2     16.0.1.12/30 [110/2] via 16.0.1.33, 00:48:02, FastEthernet0/0
O E2     16.0.1.16/30 [110/3] via 16.0.1.33, 00:48:02, FastEthernet0/0
O IA     16.0.1.20/30 [110/4] via 16.0.1.33, 00:48:08, FastEthernet0/0
O IA     16.0.1.24/30 [110/3] via 16.0.1.33, 00:48:39, FastEthernet0/0
O IA     16.0.1.28/30 [110/2] via 16.0.1.33, 00:48:39, FastEthernet0/0
C        16.0.1.32/30 is directly connected, FastEthernet0/0
L        16.0.1.34/32 is directly connected, FastEthernet0/0
O E2     16.0.1.36/30 [110/2] via 16.0.1.33, 00:48:02, FastEthernet0/0
O E2     16.0.1.40/30 [110/3] via 16.0.1.33, 00:48:02, FastEthernet0/0
O E2     16.0.1.44/30 [110/2] via 16.0.1.33, 00:48:02, FastEthernet0/0
A3-R10#
```

```
A3-R10#sh ipv6 route
IPv6 Routing Table - default - 31 entries
Codes: C - Connected, L - Local, S - Static, U - Per-user Static route
       B - BGP, HA - Home Agent, MR - Mobile Router, R - RIP
       H - NHRP, I1 - ISIS L1, I2 - ISIS L2, IA - ISIS interarea
       IS - ISIS summary, D - EIGRP, EX - EIGRP external, NM - NEMO
       ND - ND Default, NDp - ND Prefix, DCE - Destination, NDr - Redirect
       O - OSPF Intra, OI - OSPF Inter, OE1 - OSPF ext 1, OE2 - OSPF ext 2
       ON1 - OSPF NSSA ext 1, ON2 - OSPF NSSA ext 2, l - LISP
B   2222:2397:1::/48 [200/0]
     via 2222:2397:5::7
B   2222:2397:2::/48 [200/0]
     via 2222:2397:5::7
B   2222:2397:3::/48 [200/0]
     via 2222:2397:5::7
B   2222:2397:4::/48 [200/0]
     via 2222:2397:5::7
B   2222:2397:5::/48 [200/0]
     via 2222:2397:5::7
OI  2222:2397:5::1/128 [110/6]
     via FE80::1:1:9, FastEthernet0/0
OI  2222:2397:5::2/128 [110/5]
     via FE80::1:1:9, FastEthernet0/0
OI  2222:2397:5::3/128 [110/5]
     via FE80::1:1:9, FastEthernet0/0
OI  2222:2397:5::4/128 [110/4]
     via FE80::1:1:9, FastEthernet0/0
OI  2222:2397:5::5/128 [110/5]
     via FE80::1:1:9, FastEthernet0/0
OI  2222:2397:5::6/128 [110/6]
     via FE80::1:1:9, FastEthernet0/0
OI  2222:2397:5::7/128 [110/3]
     via FE80::1:1:9, FastEthernet0/0
OI  2222:2397:5::8/128 [110/2]
     via FE80::1:1:9, FastEthernet0/0
OI  2222:2397:5::9/128 [110/1]
     via FE80::1:1:9, FastEthernet0/0
LC  2222:2397:5::A/128 [0/0]
     via Loopback0, receive
OI  2222:2397:5::B/128 [110/5]
     via FE80::1:1:9, FastEthernet0/0
OI  2222:2397:5::C/128 [110/6]
     via FE80::1:1:9, FastEthernet0/0
OI  2222:2397:5:1::/64 [110/6]
     via FE80::1:1:9, FastEthernet0/0
OI  2222:2397:5:2::/64 [110/5]
     via FE80::1:1:9, FastEthernet0/0
OI  2222:2397:5:3::/64 [110/5]
     via FE80::1:1:9, FastEthernet0/0
OI  2222:2397:5:4::/64 [110/5]
     via FE80::1:1:9, FastEthernet0/0
OI  2222:2397:5:5::/64 [110/6]
     via FE80::1:1:9, FastEthernet0/0
OI  2222:2397:5:6::/64 [110/4]
     via FE80::1:1:9, FastEthernet0/0
OI  2222:2397:5:7::/64 [110/3]
     via FE80::1:1:9, FastEthernet0/0
OI  2222:2397:5:7::1/128 [110/3]
     via FE80::1:1:9, FastEthernet0/0
OI  2222:2397:5:8::/64 [110/2]
     via FE80::1:1:9, FastEthernet0/0
C   2222:2397:5:9::/64 [0/0]
     via FastEthernet0/0, directly connected
L   2222:2397:5:9::2/128 [0/0]
     via FastEthernet0/0, receive
OI  2222:2397:5:A::/64 [110/5]
     via FE80::1:1:9, FastEthernet0/0
OI  2222:2397:5:B::/64 [110/6]
     via FE80::1:1:9, FastEthernet0/0
L   FF00::/8 [0/0]
     via Null0, receive
A3-R10#
```

Figura 16- A3R10 Virtual link, IGP e BGP

```
      + - replicated route, % - next hop override

Gateway of last resort is not set

     12.0.0.0/16 is subnetted, 1 subnets
B       12.0.0.0 [200/0] via 16.0.0.3, 00:07:52
     13.0.0.0/16 is subnetted, 1 subnets
B       13.0.0.0 [200/0] via 16.0.0.3, 00:07:52
     14.0.0.0/16 is subnetted, 1 subnets
B       14.0.0.0 [200/0] via 16.0.0.3, 00:07:52
     15.0.0.0/16 is subnetted, 1 subnets
B       15.0.0.0 [200/0] via 16.0.0.3, 00:07:52
     16.0.0.0/8 is variably subnetted, 31 subnets, 3 masks
B       16.0.0.0/16 [200/0] via 16.0.0.3, 00:07:52
O IA    16.0.0.1/32 [110/2] via 16.0.1.5, 00:09:01, FastEthernet0/0
O       16.0.0.2/32 [110/1] via 16.0.1.5, 00:09:01, FastEthernet0/0
O       16.0.0.3/32 [110/1] via 16.0.1.9, 00:09:01, FastEthernet0/1
C       16.0.0.4/32 is directly connected, Loopback0
O       16.0.0.5/32 [110/1] via 16.0.1.14, 00:09:01, FastEthernet2/0
O IA    16.0.0.6/32 [110/2] via 16.0.1.14, 00:09:01, FastEthernet2/0
O       16.0.0.7/32 [110/1] via 16.0.1.22, 00:09:01, FastEthernet1/1
O IA    16.0.0.8/32 [110/2] via 16.0.1.22, 00:09:00, FastEthernet1/1
O IA    16.0.0.9/32 [110/3] via 16.0.1.22, 00:08:49, FastEthernet1/1
O E2    16.0.0.10/32 [110/20] via 16.0.1.22, 00:08:54, FastEthernet1/1
O       16.0.0.11/32 [110/1] via 16.0.1.38, 00:09:01, FastEthernet1/0
O IA    16.0.0.12/32 [110/2] via 16.0.1.38, 00:09:01, FastEthernet1/0
O IA    16.0.1.0/30 [110/2] via 16.0.1.5, 00:09:01, FastEthernet0/0
C       16.0.1.4/30 is directly connected, FastEthernet0/0
L       16.0.1.6/32 is directly connected, FastEthernet0/0
C       16.0.1.8/30 is directly connected, FastEthernet0/1
L       16.0.1.10/32 is directly connected, FastEthernet0/1
C       16.0.1.12/30 is directly connected, FastEthernet2/0
L       16.0.1.13/32 is directly connected, FastEthernet2/0
O IA    16.0.1.16/30 [110/2] via 16.0.1.14, 00:09:01, FastEthernet2/0
C       16.0.1.20/30 is directly connected, FastEthernet1/1
L       16.0.1.21/32 is directly connected, FastEthernet1/1
O IA    16.0.1.24/30 [110/2] via 16.0.1.22, 00:09:01, FastEthernet1/1
O IA    16.0.1.28/30 [110/3] via 16.0.1.22, 00:09:00, FastEthernet1/1
O E2    16.0.1.32/30 [110/20] via 16.0.1.22, 00:08:54, FastEthernet1/1
C       16.0.1.36/30 is directly connected, FastEthernet1/0
L       16.0.1.37/32 is directly connected, FastEthernet1/0
O IA    16.0.1.40/30 [110/2] via 16.0.1.38, 00:09:01, FastEthernet1/0
C       16.0.1.44/30 is directly connected, FastEthernet3/0
L       16.0.1.46/32 is directly connected, FastEthernet3/0
A3-R4#traceroute 12.0.0.1
Type escape sequence to abort.
Tracing the route to 12.0.0.1
VRF info: (vrf in name/id, vrf out name/id)
  1 16.0.1.9 20 msec 28 msec 24 msec
  2 15.0.1.17 [AS 9002] 56 msec 24 msec 48 msec
  3 15.0.1.1 [AS 9002] 72 msec 100 msec 96 msec
  4 13.0.1.17 [AS 6001] 132 msec 72 msec 124 msec
  5 13.0.1.9 [AS 6001] 124 msec 132 msec 228 msec
  6 13.0.1.1 [AS 6001] 140 msec 192 msec 172 msec
  7 12.0.1.25 [AS 6000] 140 msec 156 msec 208 msec
  8 12.0.1.5 [AS 6000] 156 msec 92 msec 188 msec
  9 12.0.1.1 [AS 6000] 160 msec 144 msec 168 msec
A3-R4#
```

Figura 17 - A3R4 rotas e direção

```
A3-R7#sh mpls forwarding-table
Local      Outgoing   Prefix           Bytes Label   Outgoing   Next Hop
Label      Label      or Tunnel Id     Switched      interface
7000       Pop Label  16.0.1.28/30     0             Fa0/0      16.0.1.26
7001       Pop Label  16.0.0.8/32      0             Fa0/0      16.0.1.26
7002       Pop Label  16.0.1.4/30      0             Fa0/1      16.0.1.21
7003       Pop Label  16.0.1.8/30      0             Fa0/1      16.0.1.21
7004       Pop Label  16.0.1.12/30     0             Fa0/1      16.0.1.21
7005       Pop Label  16.0.1.36/30     0             Fa0/1      16.0.1.21
7006       4003       16.0.0.11/32     0             Fa0/1      16.0.1.21
7007       4004       16.0.0.5/32      0             Fa0/1      16.0.1.21
7008       Pop Label  16.0.1.44/30     0             Fa0/1      16.0.1.21
7009       Pop Label  16.0.0.4/32      0             Fa0/1      16.0.1.21
7010       4000       16.0.0.3/32      0             Fa0/1      16.0.1.21
7011       4001       16.0.0.2/32      0             Fa0/1      16.0.1.21
7012       4009       16.0.0.12/32     0             Fa0/1      16.0.1.21
7013       4005       16.0.1.40/30     0             Fa0/1      16.0.1.21
7014       4006       16.0.1.16/30     0             Fa0/1      16.0.1.21
7015       4007       16.0.0.1/32      0             Fa0/1      16.0.1.21
7016       4002       16.0.1.0/30      0             Fa0/1      16.0.1.21
7017       8017       16.0.0.9/32      0             Fa0/0      16.0.1.26
7018       Pop Label  16.16.16.2/32[V] 0             aggregate/A
7019       No Label   172.16.0.2/32[V] 0             Fa1/0      192.168.0.6
Local      Outgoing   Prefix           Bytes Label   Outgoing   Next Hop
Label      Label      or Tunnel Id     Switched      interface
7020       No Label   172.16.3.0/24[V] 0             Fa1/0      192.168.0.6
7021       No Label   192.168.0.4/30[V]   \
                                       0             aggregate/A
7022       4014       16.0.0.6/32      0             Fa0/1      16.0.1.21
7023       8018       16.0.0.10/32     0             Fa0/0      16.0.1.26
7024       8019       16.0.1.32/30     0             Fa0/0      16.0.1.26
A3-R7#
```

Figura 18- MPLS