

Relatório do Projeto Final - Redes Convergentes

1. Contexto e objetivos

- Trabalho em dupla avaliado na 3ª atividade, com entrega do arquivo do Packet Tracer e relatório conforme enunciado do PDF **trabalho final 2025-2 redes.pdf**.
- Tecnologias obrigatórias: roteamento dinâmico com RIP, OSPF e BGP; serviços de DHCP e VoIP (Cisco CME); capacidade de explicar comandos e escolhas de topologia.
- Objetivos de aprendizagem atendidos: configuração e integração dos protocolos, interligação entre AS distintos, e validação de conectividade entre hosts.

2. Visão geral da topologia

- Três Sistemas Autônomos interligados:
 - **AS 65001 (RIP)**: R1 e R2, LANs 192.168.1.0/24 e 192.168.2.0/24, enlace interno 10.1.1.0/30.
 - **AS 65002 (OSPF)**: R3 (Área 0/ABR), R4 (Área 1), R5 (Área 2); enlances internos 10.2.1.0/30 (Área 1) e 10.2.2.0/30 (Área 2); LANs 192.168.3.0/24 e 192.168.5.0/24.
 - **AS 65003 / AS 65004 (BGP de borda)**: R6 (65003) liga AS 65001-65002; R7 (65004) faz peering com R2 (65001), R4 (65002) e R6 (65003).
- Serviços adicionais na borda do AS 65001: roteador de voz (CME) em 192.168.1.100/24 atendendo a mesma LAN do R1.
- Evidências visuais disponíveis nos prints, por exemplo **Topologia Geral.png** (desenho completo) e **Vizinhança-BGP-*.png** (peers BGP).

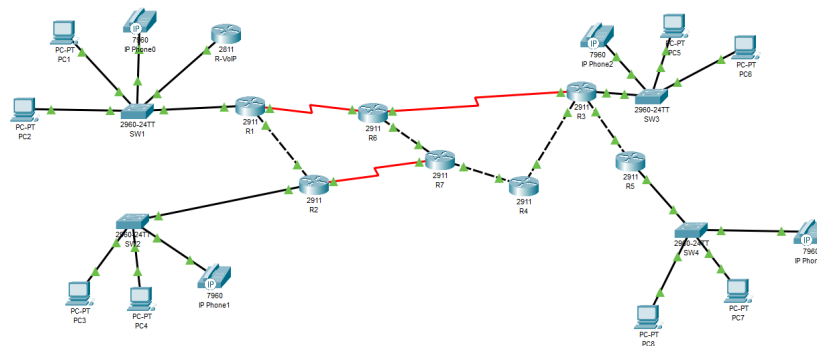
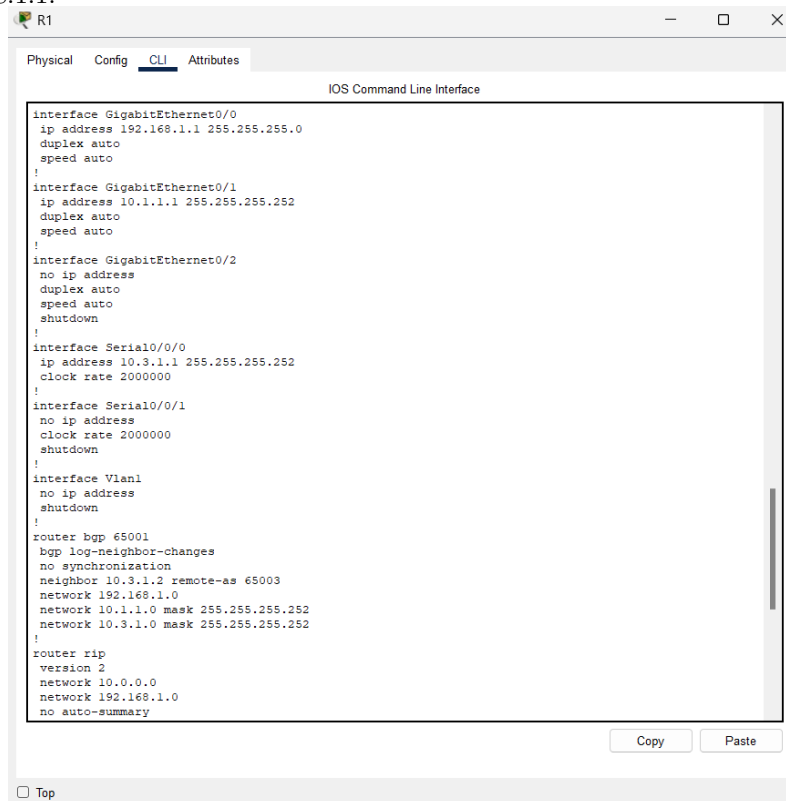


Figure 1: Topologia Geral

3. Endereçamento e papéis por equipamento

AS 65001 - RIP

- **R1 (### R1 - Principais Configurações.txt):**
 - G0/0 192.168.1.1/24 (LAN dados/voz), G0/1 10.1.1.1/30 (para R2), S0/0/0 10.3.1.1/30 (para R6).
 - RIP v2 em 192.168.1.0, 10.1.1.0, 10.3.1.0; BGP 65001 com neighbor 10.3.1.2 (R6/AS65003), anuncio 192.168.1.0 e redistribuição do RIP.
 - DHCP VOICE na LAN 192.168.1.0 com option 150 apontando para 192.168.1.1.



```
interface GigabitEthernet0/0
ip address 192.168.1.1 255.255.255.0
duplex auto
speed auto
!
interface GigabitEthernet0/1
ip address 10.1.1.1 255.255.255.252
duplex auto
speed auto
!
interface GigabitEthernet0/2
no ip address
duplex auto
speed auto
shutdown
!
interface Serial0/0/0
ip address 10.3.1.1 255.255.255.252
clock rate 2000000
!
interface Serial0/0/1
no ip address
clock rate 2000000
shutdown
!
interface Vlan1
no ip address
shutdown
!
router bgp 65001
bgp log-neighbor-changes
no synchronization
neighbor 10.3.1.2 remote-as 65003
network 192.168.1.0
network 10.1.1.0 mask 255.255.255.252
network 10.3.1.0 mask 255.255.255.252
!
router rip
version 2
network 10.0.0.0
network 192.168.1.0
no auto-summary
```

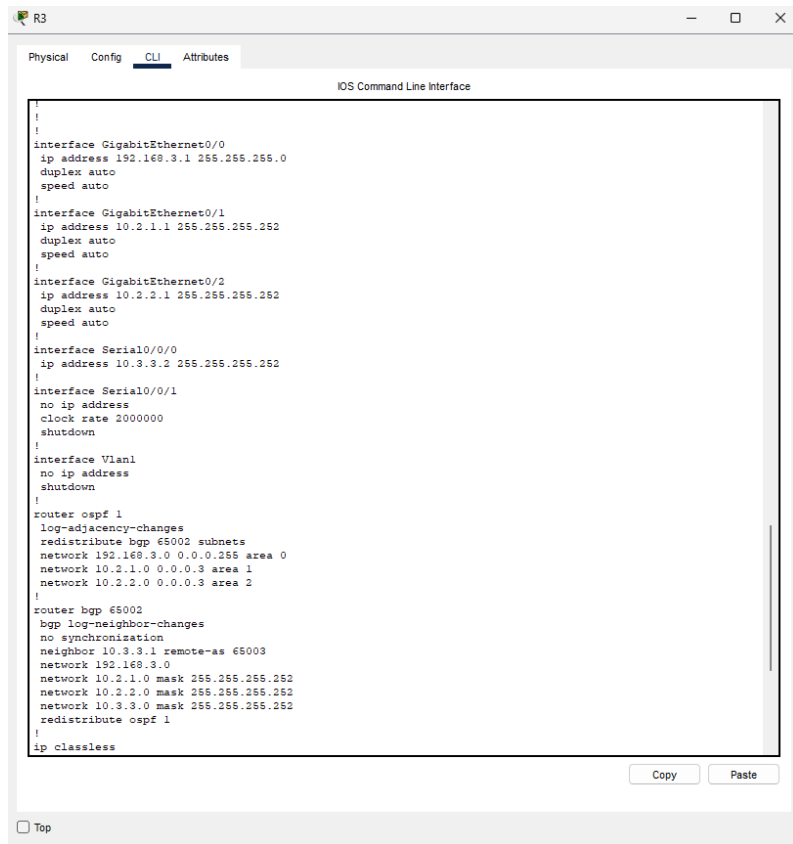
- Prints:
- **R2 (### R2 - Roteador RIP (AS 65001).txt):**
 - G0/0 192.168.2.1/24, G0/1 10.1.1.2/30 (para R1), S0/0/0 10.3.2.1/30 (para R7).
 - RIP v2 para 10.0.0.0 e 192.168.2.0; BGP 65001 com neighbor 10.3.2.2 (R7/AS65004), anúncios 192.168.2.0, 10.1.1.0/30 e 10.3.2.0/30.

```
interface GigabitEthernet0/0
ip address 192.168.2.1 255.255.255.0
duplex auto
speed auto
!
interface GigabitEthernet0/1
ip address 10.1.1.2 255.255.255.252
duplex auto
speed auto
!
interface GigabitEthernet0/2
no ip address
duplex auto
speed auto
shutdown
!
interface Serial10/0/0
ip address 10.3.2.1 255.255.255.252
clock rate 2000000
!
interface Serial10/0/1
no ip address
clock rate 2000000
shutdown
!
interface Vlan1
no ip address
shutdown
!
router bgp 65001
bgp log-neighbor-changes
no synchronization
neighbor 10.3.2.2 remote-as 65004
network 192.168.2.0
network 10.1.1.0 mask 255.255.255.252
network 10.3.2.0 mask 255.255.255.252
!
router ospf 1
version 2
network 10.0.0.0
network 192.168.2.0
no auto-summary
!
ip classless
!
ip flow-export version 9
!
!
```

– Prints:

AS 65002 - OSPF

- **R3 (Área 0/ABR) (### R3 - Roteador OSPF.txt):**
 - G0/0 192.168.3.1/24 (Área 0), G0/1 10.2.1.1/30 (Área 1), G0/2 10.2.2.1/30 (Área 2), S0/0/0 10.3.3.2/30 (para R6).
 - OSPF 1 com redes em suas áreas; redistribui BGP 65002. BGP 65002 com neighbor 10.3.3.1 (R6/AS65003), anúncios das redes internas e redistribuição do OSPF.

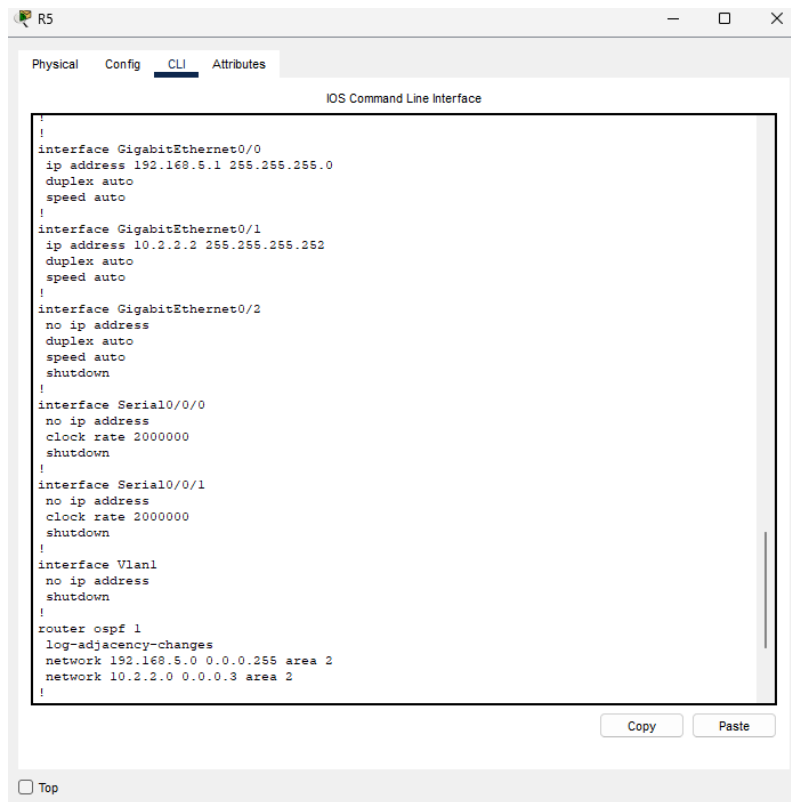


```
!
!
interface GigabitEthernet0/0
ip address 192.168.3.1 255.255.255.0
duplex auto
speed auto
!
interface GigabitEthernet0/1
ip address 10.2.1.1 255.255.255.252
duplex auto
speed auto
!
interface GigabitEthernet0/2
ip address 10.2.2.1 255.255.255.252
duplex auto
speed auto
!
interface Serial0/0/0
ip address 10.3.3.2 255.255.255.252
!
interface Serial0/0/1
no ip address
clock rate 2000000
shutdown
!
interface Vlan1
no ip address
shutdown
!
router ospf 1
log-adjacency-changes
redistribute bgp 65002 subnets
network 192.168.3.0 0.0.0.255 area 0
network 10.2.1.0 0.0.0.3 area 1
network 10.2.2.0 0.0.0.3 area 2
!
router bgp 65002
bgp log-neighbor-changes
no synchronization
neighbor 10.3.3.1 remote-as 65003
network 192.168.3.0
network 10.2.1.0 mask 255.255.255.252
network 10.2.2.0 mask 255.255.255.252
network 10.3.3.0 mask 255.255.255.252
redistribute ospf 1
!
ip classless
```

- Prints:
- **R4 (Área 1) (###R4 - Roteador OSPF Área 1 BGP AS 6.txt):**
 - G0/0 10.2.1.2/30 (Área 1), G0/1 10.3.4.2/30 (para R7).
 - OSPF 1 anunciando 10.2.1.0/30; BGP 65002 com neighbor 10.3.4.1 (R7/AS65004), anúncios 10.2.1.0/30 e 10.3.4.0/30; redistribuição OSPF<->BGP.

```
interface GigabitEthernet0/0
ip address 10.2.1.2 255.255.255.252
duplex auto
speed auto
!
interface GigabitEthernet0/1
ip address 10.3.4.2 255.255.255.252
duplex auto
speed auto
!
interface GigabitEthernet0/2
no ip address
duplex auto
speed auto
shutdown
!
interface Serial0/0/0
no ip address
clock rate 2000000
shutdown
!
interface Serial0/0/1
no ip address
clock rate 2000000
shutdown
!
interface Vlan1
no ip address
shutdown
!
router ospf 1
log-adjacency-changes
redistribute bgp 65002 subnets
network 10.2.1.0 0.0.0.3 area 1
!
router bgp 65002
bgp log-neighbor-changes
no synchronization
neighbor 10.3.4.1 remote-as 65004
network 10.2.1.0 mask 255.255.255.252
network 10.3.4.0 mask 255.255.255.252
redistribute ospf 1
!
```

- Prints:
- **R5 (Área 2) (###R5 - Roteador OSPF Área 2.txt):**
 - G0/0 192.168.5.1/24 (LAN Área 2), G0/1 10.2.2.2/30 (link para R3).
 - OSPF 1 anunciando 192.168.5.0/24 e 10.2.2.0/30 na Área 2.



The screenshot shows a window titled 'R5' with tabs for 'Physical', 'Config', 'CLI', and 'Attributes'. The 'CLI' tab is active, displaying the 'IOS Command Line Interface'. The configuration commands are as follows:

```
!
interface GigabitEthernet0/0
ip address 192.168.5.1 255.255.255.0
duplex auto
speed auto
!
interface GigabitEthernet0/1
ip address 10.2.2.2 255.255.255.252
duplex auto
speed auto
!
interface GigabitEthernet0/2
no ip address
duplex auto
speed auto
shutdown
!
interface Serial0/0/0
no ip address
clock rate 2000000
shutdown
!
interface Serial0/0/1
no ip address
clock rate 2000000
shutdown
!
interface Vlan1
no ip address
shutdown
!
router ospf 1
log-adjacency-changes
network 192.168.5.0 0.0.0.255 area 2
network 10.2.2.0 0.0.0.3 area 2
!
```

At the bottom right of the CLI window are 'Copy' and 'Paste' buttons. Below the CLI window is a 'Prints:' label and a 'Top' button.

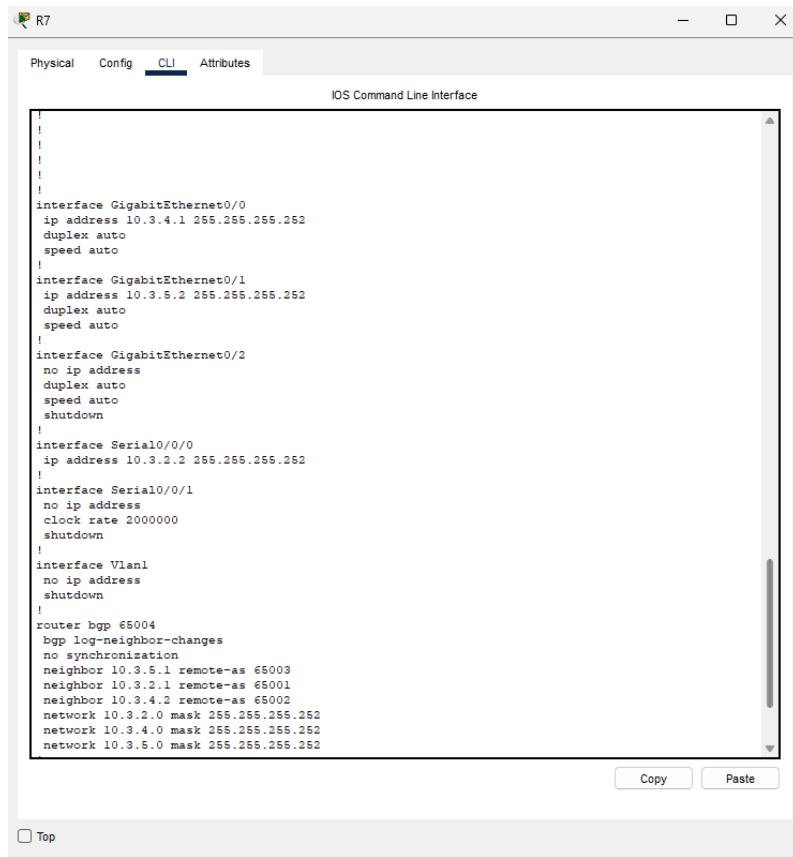
– Prints:

AS 65003 / AS 65004 - BGP de borda

- **R6 (AS 65003)** (R6 - Roteador BGP (AS 65003).txt):
 - S0/0/0 10.3.1.2/30 (para R1/AS65001), S0/0/1 10.3.3.1/30 (para R3/AS65002), G0/0 10.3.5.1/30 (para R7/AS65004).
 - BGP 65003 com neighbors 10.3.1.1 (AS65001) e 10.3.3.2 (AS65002); anúncios das três redes ponto-a-ponto. (*Observação: para formar sessão com o R7/AS65004 seria preciso adicionar neighbor 10.3.5.2 remote-as 65004, caso desejado.*)

```
!
interface GigabitEthernet0/0
ip address 10.3.5.1 255.255.255.252
duplex auto
speed auto
!
interface GigabitEthernet0/1
no ip address
duplex auto
speed auto
shutdown
!
interface GigabitEthernet0/2
no ip address
duplex auto
speed auto
shutdown
!
interface Serial0/0/0
ip address 10.3.1.2 255.255.255.252
!
interface Serial0/0/1
ip address 10.3.3.1 255.255.255.252
clock rate 2000000
!
interface Vlan1
no ip address
shutdown
!
router bgp 65003
bgp log-neighbor-changes
no synchronization
neighbor 10.3.1.1 remote-as 65001
neighbor 10.3.3.2 remote-as 65002
network 10.3.1.0 mask 255.255.255.252
network 10.3.3.0 mask 255.255.255.252
network 10.3.5.0 mask 255.255.255.252
!
ip classless
!
```

- Prints: ☐ Top
- **R7 (AS 65004)** (R7 - Roteador BGP (AS 65004).txt):
 - S0/0/0 10.3.2.2/30 (para R2/AS65001), G0/0 10.3.4.1/30 (para R4/AS65002), G0/1 10.3.5.2/30 (para R6/AS65003).
 - BGP 65004 com neighbors 10.3.2.1 (AS65001), 10.3.4.2 (AS65002) e 10.3.5.1 (AS65003); anúncios das três redes de enlace.



– Prints:

Roteador de Voz (CME)

- **R-VoIP** (R-VoIP - Roteador VoIP (DHCP, RIP, .txt):
 - Fa0/0 192.168.1.100/24 servindo a LAN de voz/dados; DHCP VOICE com gateway 192.168.1.100 e option 150 apontando para o próprio roteador.
 - RIP v2 anunciando 192.168.1.0/24 para integração com R1.
 - Cisco CME com 4 ramais (2000-2003) e ip source-address 192.168.1.100 port 2000; um ephone pré-cadastrado (MAC 0001.C762.EAB0) do tipo 7960. Print show ephone.png registra o estado dos telefones.

4. Protocolos e redistribuição

- **RIP (AS 65001)**: Versão 2, sem sumarização automática; R1 anuncia LAN 192.168.1.0 e links 10.1.1.0/30 e 10.3.1.0/30; R2 anuncia

192.168.2.0/24 e 10.1.1.0/30. R1 redistribui o RIP no BGP 65001 para exportar rotas internas ao AS 65003.

- **OSPF (AS 65002):** Área 0 no R3 (com LAN 192.168.3.0/24), Área 1 entre R3-R4 (10.2.1.0/30) e Área 2 entre R3-R5 (10.2.2.0/30 e LAN 192.168.5.0/24). R3 e R4 redistribuem BGP<->OSPF, permitindo anúncio das redes OSPF no BGP 65002.
- **BGP (inter-AS):**
 - AS 65001: R1 faz peering com R6 (AS65003), anunciando 192.168.1.0/24 e redistribuição do RIP; R2 faz peering com R7 (AS65004), anunciando 192.168.2.0/24 e links internos.
 - AS 65002: R3 (para R6/AS65003) e R4 (para R7/AS65004) exportam redes OSPF.
 - AS 65003: R6 recebe rotas dos AS 65001 e 65002 e publica os enlaces 10.3.1.0/30, 10.3.3.0/30 e 10.3.5.0/30.
 - AS 65004: R7 agrega conectividade extra entre 65001, 65002 e 65003.
 - Prints Vizinhança-BGP-*.png documentam o estabelecimento das sessões.
- **Pontos de atenção:** (1) garantir a sessão BGP R6<->R7 se for necessária para redundância pelo enlace 10.3.5.0/30; (2) evitar sobreposição de serviços DHCP na LAN 192.168.1.0/24 escolhendo apenas um servidor (R1 ou R-VoIP) para distribuição de IPs/option 150.

```
R1#show ip bgp summary
BGP router identifier 192.168.1.1, local AS number 65001
BGP table version is 11, main routing table version 6
10 network entries using 1320 bytes of memory
10 path entries using 520 bytes of memory
7/6 BGP path/bestpath attribute entries using 1196 bytes of memory
3 BGP AS-PATH entries using 72 bytes of memory
0 BGP route-map cache entries using 0 bytes of memory
0 BGP filter-list cache entries using 0 bytes of memory
Bitfield cache entries: current 1 (at peak 1) using 32 bytes of memory
BGP using 3140 total bytes of memory
BGP activity 9/0 prefixes, 10/0 paths, scan interval 60 secs

Neighbor      V    AS MsgRcvd MsgSent  TblVer  InQ OutQ Up/Down  State/PfxRcd
10.3.1.2       4 65003     69     59      11    0    0 00:57:00      4
```

```

R2>enable
R2#show ip bgp summary
BGP router identifier 192.168.2.1, local AS number 65001
BGP table version is 11, main routing table version 6
10 network entries using 1320 bytes of memory
10 path entries using 520 bytes of memory
7/6 BGP path/bestpath attribute entries using 1196 bytes of memory
3 BGP AS-PATH entries using 72 bytes of memory
0 BGP route-map cache entries using 0 bytes of memory
0 BGP filter-list cache entries using 0 bytes of memory
Bitfield cache entries: current 1 (at peak 1) using 32 bytes of memory
BGP using 3140 total bytes of memory
BGP activity 9/0 prefixes, 10/0 paths, scan interval 60 secs

Neighbor      V    AS MsgRcvd MsgSent  TblVer  InQ OutQ Up/Down  State/PfxRcd
10.3.2.2       4 65004      67     59      11    0    0 00:57:58      4

R3#show ip bgp summary
BGP router identifier 192.168.3.1, local AS number 65002
BGP table version is 20, main routing table version 6
10 network entries using 1320 bytes of memory
10 path entries using 520 bytes of memory
5/4 BGP path/bestpath attribute entries using 828 bytes of memory
3 BGP AS-PATH entries using 72 bytes of memory
0 BGP route-map cache entries using 0 bytes of memory
0 BGP filter-list cache entries using 0 bytes of memory
Bitfield cache entries: current 1 (at peak 1) using 32 bytes of memory
BGP using 2772 total bytes of memory
BGP activity 9/0 prefixes, 10/0 paths, scan interval 60 secs

Neighbor      V    AS MsgRcvd MsgSent  TblVer  InQ OutQ Up/Down  State/PfxRcd
10.3.3.1       4 65003      68     61      20    0    0 00:59:07      4

R4#show ip bgp summary
BGP router identifier 10.3.4.2, local AS number 65002
BGP table version is 17, main routing table version 6
10 network entries using 1320 bytes of memory
10 path entries using 520 bytes of memory
5/4 BGP path/bestpath attribute entries using 828 bytes of memory
3 BGP AS-PATH entries using 72 bytes of memory
0 BGP route-map cache entries using 0 bytes of memory
0 BGP filter-list cache entries using 0 bytes of memory
Bitfield cache entries: current 1 (at peak 1) using 32 bytes of memory
BGP using 2772 total bytes of memory
BGP activity 9/0 prefixes, 10/0 paths, scan interval 60 secs

Neighbor      V    AS MsgRcvd MsgSent  TblVer  InQ OutQ Up/Down  State/PfxRcd
10.3.4.1       4 65004      69     61      17    0    0 00:59:52      4

```

5. Serviços de rede

- DHCP:
 - R1: pool VOICE 192.168.1.0/24 com option 150 em 192.168.1.1.
 - R-VoIP: pool VOICE 192.168.1.0/24 com gateway e option 150 em 192.168.1.100; exclui 192.168.1.1-192.168.1.99.
 - Recomenda-se manter apenas o servidor do R-VoIP ativo para voz, deixando o de R1 desativado ou ajustado para outra sub-rede/dados.

- **VoIP (CME):** 4 ramais (2000-2003) auto-atribuídos, um telefone 7960 pré-registrado; **telephony-service** limitado a 4 ephones/dial-peers, adequado para laboratório. Arquivo **show ephone.png** confirma o provisionamento.

```
R-VoIP#show ephone

ephone-1 Mac:0001.C762.EAB0 TCP socket:[1] activeLine:1 UNREGISTERED
mediaActive:0 offhook:1 ringing:0 reset:0 reset_sent:0 paging 0 debug:0 caps:8
IP:0.0.0.0 0 7960 keepalive 43 max_line 2
button 1: dn 1 number 2000 CH1 DOWN
```

– Print: R-VoIP#

6. Testes e evidências de funcionamento

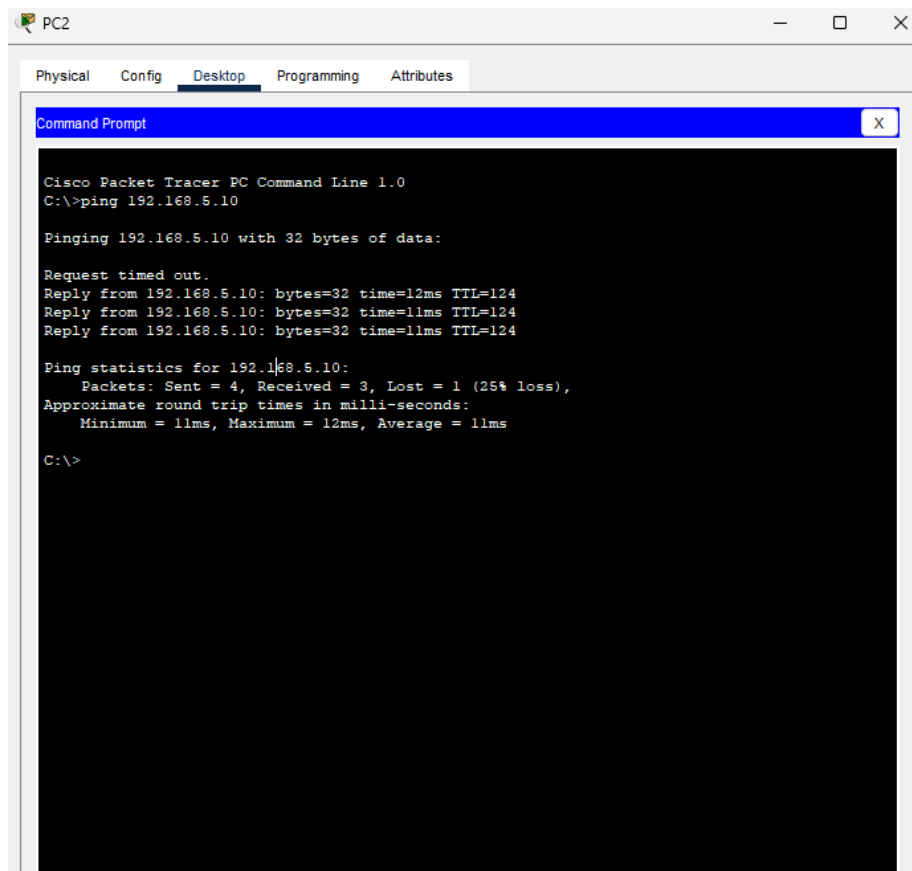
- **Conectividade entre AS:** capturas **Teste-PC1 para PC5.png**, **Teste-PC2 para PC7.png** e **Teste-PC4 para PC8.png** registram pings entre hosts de AS diferentes, demonstrando troca de rotas entre RIP, OSPF e BGP.
- **Protocolos ativos:** **show ip protocols R1.png** evidencia RIP ativo e (via configuração) redistribuição para BGP. Tabelas de roteamento (**R1-tabela de roteamento IPv4.png**, **R3-tabela de roteamento IPv4.png**) mostram aprendizado dinâmico nas três pilhas de roteamento.
- **BGP:** **Vizinhança-BGP-R1.png** a **Vizinhança-BGP-R4.png** registram as sessões de peering por AS e os estados de vizinhança.
- **VoIP:** **show ephone.png** verifica o status dos telefones IP cadastrados pelo CME.
- Sugestão de checagens rápidas adicionais: **ping** entre todos os pares de LAN (192.168.1.0, .2.0, .3.0, .5.0), **traceroute** para confirmar o caminho via AS, **show ip bgp summary** em R6/R7 para validar as sessões, e **show ip dhcp binding** no servidor ativo da LAN 192.168.1.0/24.

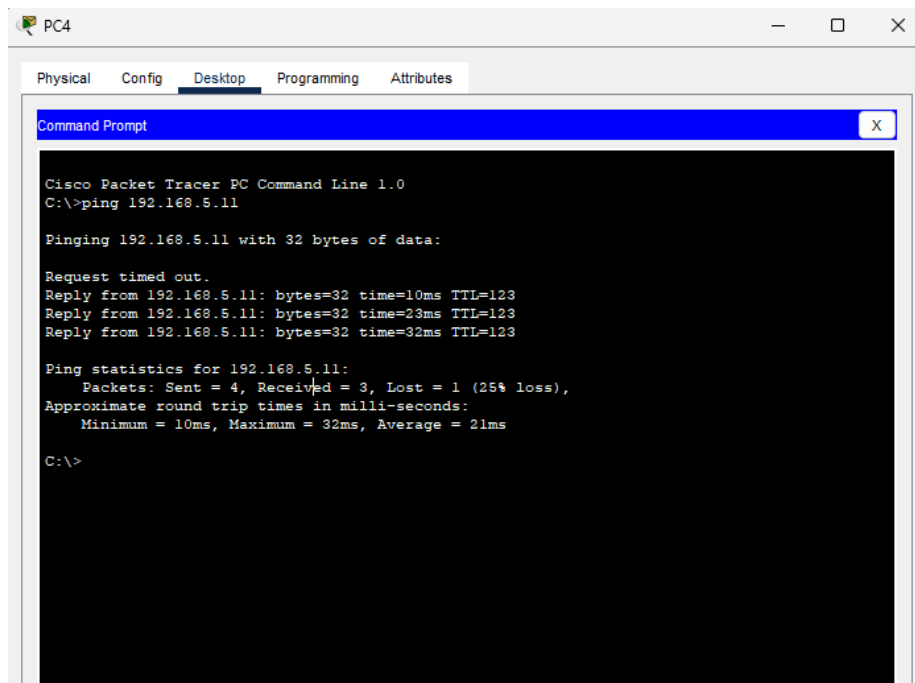
```
C:\>ping 192.168.3.10

Pinging 192.168.3.10 with 32 bytes of data:

Request timed out.
Reply from 192.168.3.10: bytes=32 time=10ms TTL=125
Reply from 192.168.3.10: bytes=32 time=10ms TTL=125
Reply from 192.168.3.10: bytes=32 time=24ms TTL=125

Ping statistics for 192.168.3.10:
    Packets: Sent = 4, Received = 3, Lost = 1 (25% loss),
    Approximate round trip times in milli-seconds:
        Minimum = 10ms, Maximum = 24ms, Average = 14ms
```

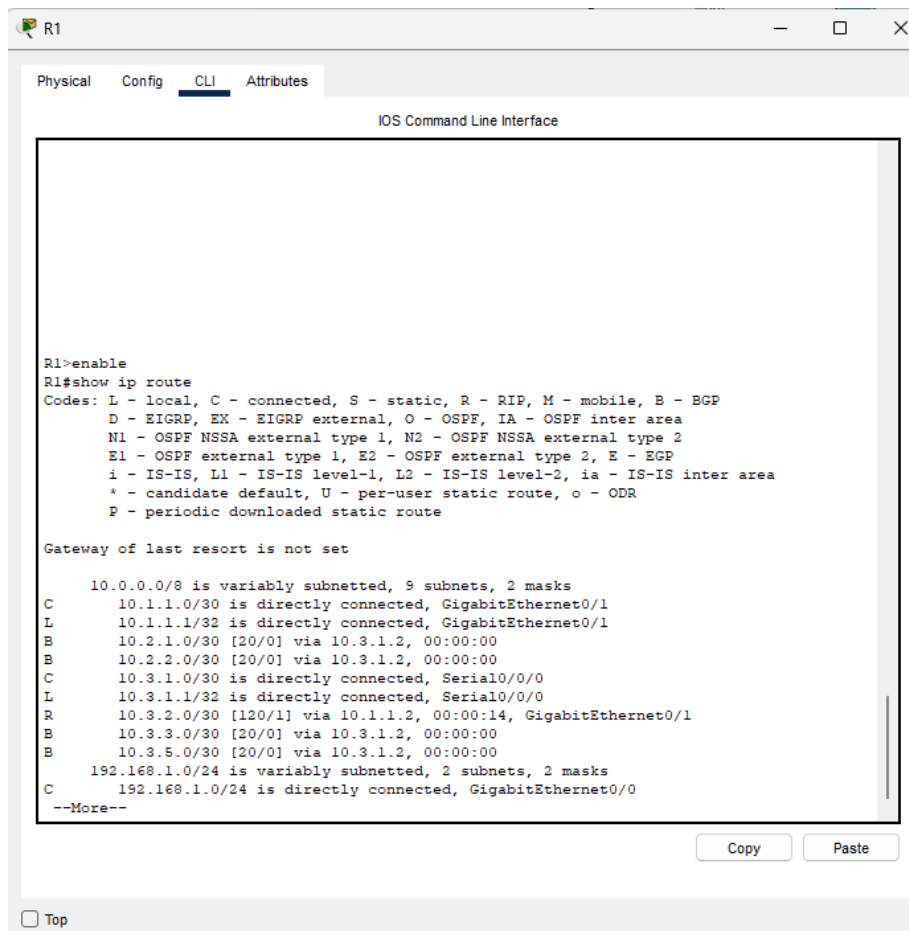




```

R1#show ip protocols
Routing Protocol is "bgp 65001"
  Outgoing update filter list for all interfaces is not set
  Incoming update filter list for all interfaces is not set
  IGP synchronization is disabled
  Automatic route summarization is disabled
  Neighbor(s):
    Address          FiltIn FiltOut DistIn DistOut Weight RouteMap
    10.3.1.2
  Maximum path: 1
  Routing Information Sources:
    Gateway          Distance      Last Update
    10.3.1.2          20           00:00:00
  Distance: external 20 internal 200 local 200
Routing Protocol is "rip"
  Sending updates every 30 seconds, next due in 15 seconds
  Invalid after 180 seconds, hold down 180, flushed after 240
  Outgoing update filter list for all interfaces is not set
  Incoming update filter list for all interfaces is not set
  Redistributing: rip
  Default version control: send version 2, receive 2
    Interface          Send Recv Triggered RIP Key-chain
    GigabitEthernet0/0  22
    GigabitEthernet0/1  22
    Serial0/0/0         22
  Automatic network summarization is not in effect
  Maximum path: 4
  Routing for Networks:
    10.0.0.0
    192.168.1.0
  Passive Interface(s):
  Routing Information Sources:
    Gateway          Distance      Last Update
    10.1.1.2          120          00:00:12
  Distance: (default is 120)

```



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

Gateway of last resort is not set

10.0.0.0/8 is variably subnetted, 11 subnets, 2 masks
B       10.1.1.0/30 [20/0] via 10.3.3.1, 00:00:00
C       10.2.1.0/30 is directly connected, GigabitEthernet0/1
L       10.2.1.1/32 is directly connected, GigabitEthernet0/1
C       10.2.2.0/30 is directly connected, GigabitEthernet0/2
L       10.2.2.1/32 is directly connected, GigabitEthernet0/2
B       10.3.1.0/30 [20/0] via 10.3.3.1, 00:00:00
O E2    10.3.2.0/30 [110/20] via 10.2.1.2, 00:54:35, GigabitEthernet0/1
C       10.3.3.0/30 is directly connected, Serial0/0/0
L       10.3.3.2/32 is directly connected, Serial0/0/0
O E2    10.3.4.0/30 [110/20] via 10.2.1.2, 00:54:35, GigabitEthernet0/1
B       10.3.5.0/30 [20/0] via 10.3.3.1, 00:00:00
--More--
```

7. Conclusão

- A topologia integra RIP (AS 65001), OSPF multiárea (AS 65002) e BGP entre AS, conforme os objetivos do projeto.
- Os serviços de DHCP e VoIP (CME) estão configurados e documentados, incluindo opção 150 e ramais provisionados.
- As sessões BGP apresentam vizinhanças estabelecidas e anúncios das rotas internas, conforme os prints de peering.
- Os testes de conectividade entre PCs de diferentes AS comprovam a troca de rotas e a comunicação fim a fim pelas três pilhas de roteamento.