

TP CCSN

Rapport de Routage (BGP + OSPF Multi-Area)

Projet E5 – Architecture Réseau Sécurisée

Réalisé par **Lilo BENNARDO & Ilyan TAYBI**

Vue d'ensemble des interconnexions ISP ↔ Paris ↔ Lyon ↔ Marseille avec BGP, OSPF et VPN.

Sommaire

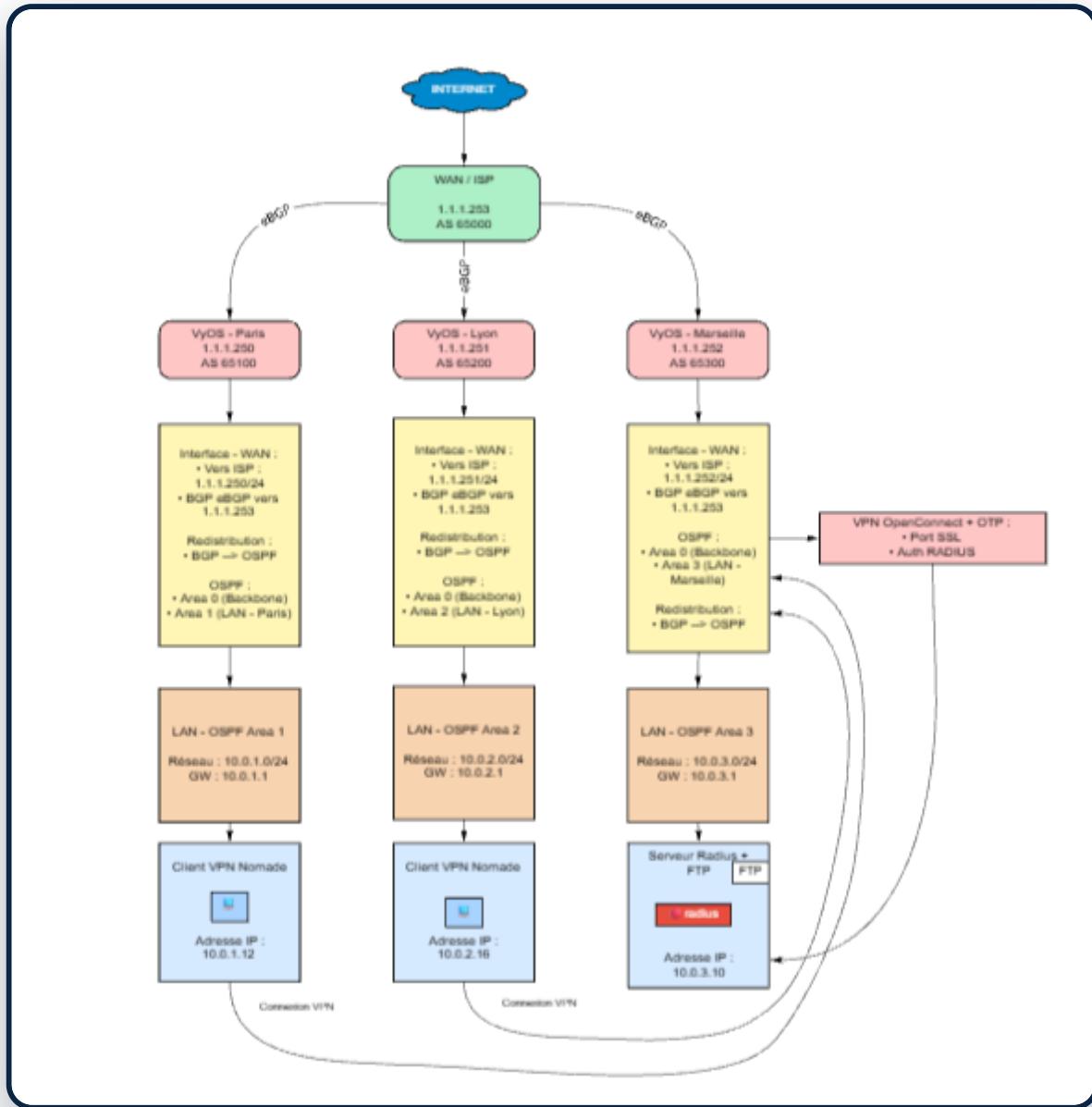
1. [Introduction](#)
2. [Schéma du réseau](#)
3. [Configuration IP sur chaque routeur](#)
4. [Configuration BGP](#)
5. [Configuration OSPF multi-area](#)
6. [Redistribution BGP ↔ OSPF](#)
7. [Tests de connectivité](#)
8. [Analyse Wireshark](#)
9. [Configuration VPN](#)
10. [Conclusion](#)

Introduction

Ce rapport présente, sous la responsabilité de **Lilo BENNARDO** et **Ilyan TAYBI**, la conception et la mise en œuvre d'une architecture multi-sites reposant sur BGP, OSPF multi-area, redistribution contrôlée, VPN OpenConnect et services Radius/FTP sécurisés. L'objectif est de documenter une chaîne technique opérationnelle, depuis la planification des préfixes jusqu'aux preuves de fonctionnement observées durant l'E5.

1. Schéma du réseau

(Insérer ici votre schéma réseau annoté : AS, IP WAN, LAN, Areas OSPF, liens BGP)



1.1 Table de routage – ISP (AS 65000)

DESTINATION	PRÉFIXE	PROTOCOLE	NEXT-HOP	INTERFACE	COMMENTAIRE
0.0.0.0/0	par défaut	Static	192.168.80.2	eth0	Sortie vers Internet / réseau externe
1.1.1.248/29	WAN	Connected	—	eth1	Réseau WAN vers Paris / Lyon / Marseille

DESTINATION	PRÉFIXE	PROTOCOLE	NEXT-HOP	INTERFACE	COMMENTAIRE
10.0.1.0/24	LAN Paris	BGP	1.1.1.250	eth1	Reçu de Paris (AS 65100)
10.0.2.0/24	LAN Lyon	BGP	1.1.1.251	eth1	Reçu de Lyon (AS 65200)
10.0.3.0/24	LAN Mars.	BGP	1.1.1.252	eth1	Reçu de Marseille (AS 65300)
192.168.80.0/24	Mgmt	Connected	—	eth0	Réseau de gestion de l'ISP

1.2 Table de routage – Paris (AS 65100)

DESTINATION	PRÉFIXE	PROTOCOLE	NEXT-HOP	INTERFACE	COMMENTAIRE
0.0.0.0/0	par défaut	Static	1.1.1.253	eth2	Sortie vers l'ISP
1.1.1.248/29	WAN	Connected	—	eth2	Réseau WAN commun via ISP
10.0.1.0/24	LAN Paris	Connected	—	eth3	Réseau local du site Paris
10.0.2.0/24	LAN Lyon	BGP	1.1.1.251	eth2	Appris en eBGP via ISP
10.0.3.0/24	LAN Mars.	BGP	1.1.1.252	eth2	Appris en eBGP via ISP

1.3 Table de routage – Lyon (AS 65200)

DESTINATION	PRÉFIXE	PROTOCOLE	NEXT-HOP	INTERFACE	COMMENTAIRE
0.0.0.0/0	par défaut	Static	1.1.1.253	eth2	Sortie vers l'ISP (ou 1.1.1.250 selon TP)
1.1.1.248/29	WAN	Connected	—	eth2	Réseau WAN commun via ISP

DESTINATION	PRÉFIXE	PROTOCOLE	NEXT-HOP	INTERFACE	COMMENTAIRE
10.0.2.0/24	LAN Lyon	Connected	—	eth3	Réseau local du site Lyon
10.0.1.0/24	LAN Paris	BGP	1.1.1.250	eth2	Appris en eBGP via ISP
10.0.3.0/24	LAN Mars.	BGP	1.1.1.252	eth2	Appris en eBGP via ISP

1.4 Table de routage – Marseille (AS 65300)

DESTINATION	PRÉFIXE	PROTOCOLE	NEXT-HOP	INTERFACE	COMMENTAIRE
0.0.0.0/0	par défaut	Static	1.1.1.253	eth2	Sortie vers l'ISP
1.1.1.248/29	WAN	Connected	—	eth2	Réseau WAN commun via ISP
10.0.3.0/24	LAN Mars.	Connected	—	eth3	Réseau local du site Marseille
10.0.1.0/24	LAN Paris	BGP	1.1.1.250	eth2	Appris en eBGP via ISP
10.0.2.0/24	LAN Lyon	BGP	1.1.1.251	eth2	Appris en eBGP via ISP

1.5 Résumé : Pourquoi utiliser un /29 au lieu d'un /24 ?

WAN ciblé, LAN confortables :

- Un **/29** fournit exactement quatre IP utilisables côté clients + l'ISP, idéal pour la boucle WAN.
- Ce format est classique sur les interconnexions BGP entre systèmes autonomes et limite la surface exposée.
- La table de routage reste compacte, lisible et cohérente avec la logique *WAN = interconnexion / LAN = grands segments*.

/29 = réaliste, efficace, sécurisé, optimisé.

/24 = trop grand pour un WAN partagé.

2. Configuration IP sur chaque routeur

2.1 ISP

```
set interfaces ethernet eth0 address 192.168.80.10/24
set interfaces ethernet eth1 address 1.1.1.253/29
commit
save
```

2.2 Paris

```
set interfaces ethernet eth2 address 1.1.1.250/29
set interfaces ethernet eth3 address 10.0.1.250/24
commit
save
```

2.3 Lyon

```
set interfaces ethernet eth2 address 1.1.1.251/29
set interfaces ethernet eth3 address 10.0.2.250/24
commit
save
```

2.4 Marseille

```
set interfaces ethernet eth2 address 1.1.1.252/29
set interfaces ethernet eth3 address 10.0.3.250/24
commit
save
```

3. Configuration BGP

3.1 ISP (AS 65000)

```
set protocols bgp system-as 65000
set protocols bgp parameters router-id 1.1.1.253
set protocols bgp neighbor 1.1.1.250 remote-as 65100
set protocols bgp neighbor 1.1.1.250 address-family ipv4-unicast
set protocols bgp neighbor 1.1.1.251 remote-as 65200
set protocols bgp neighbor 1.1.1.251 address-family ipv4-unicast
```

```
set protocols bgp neighbor 1.1.1.252 remote-as 65300
set protocols bgp neighbor 1.1.1.252 address-family ipv4-unicast
commit
save
```

Vérification – show bgp summary

```
vyos@ISP# run show bgp summary

IPv4 Unicast Summary (VRF default):
BGP router identifier 1.1.1.253, local AS number 65000 vrf-id 0
BGP table version 3
RIB entries 5, using 480 bytes of memory
Peers 3, using 60 KiB of memory

Neighbor      V      AS  MsgRcvd  MsgSent  TblVer  InQ  OutQ  Up/Down State/PfxRcd  PfxSnt Desc
1.1.1.250     4      65100    103      103      3        0      0  01:37:04          1      3 N/A
1.1.1.251     4      65200    97       97      3        0      0  01:31:19          1      3 N/A
1.1.1.252     4      65300    96       96      3        0      0  01:30:39          1      3 N/A

Total number of neighbors 3
[edit]
vyos@ISP#
```

Vérification – show ip route

```
vyos@ISP# run 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

S>* 0.0.0.0/0 [1/0] via 192.168.80.2, eth0, weight 1, 02:22:17
O  1.1.1.248/29 [110/1] is directly connected, eth1, weight 1, 00:37:42
C>* 1.1.1.248/29 is directly connected, eth1, 01:21:27
O  10.0.1.0/24 [110/2] via 1.1.1.250, eth1, weight 1, 00:21:23
B>* 10.0.1.0/24 [20/0] via 1.1.1.250, eth1, weight 1, 01:21:27
O  10.0.2.0/24 [110/2] via 1.1.1.251, eth1, weight 1, 00:19:13
B>* 10.0.2.0/24 [20/0] via 1.1.1.251, eth1, weight 1, 01:21:27
O  10.0.3.0/24 [110/2] via 1.1.1.252, eth1, weight 1, 00:18:03
B>* 10.0.3.0/24 [20/0] via 1.1.1.252, eth1, weight 1, 01:21:27
C>* 192.168.80.0/24 is directly connected, eth0, 02:22:20
[edit]
vyos@ISP#
```

3.2 Paris (AS 65100)

```
set protocols bgp system-as 65100
set protocols bgp parameters router-id 1.1.1.250
set protocols bgp neighbor 1.1.1.253 remote-as 65000
set protocols bgp neighbor 1.1.1.253 address-family ipv4-unicast
set protocols bgp address-family ipv4-unicast network 10.0.1.0/24
commit
save
```

Vérification – show bgp summary

```
vyos@PARIS:~$ show bgp summary

IPv4 Unicast Summary (VRF default):
BGP router identifier 1.1.1.250, local AS number 65100 vrf-id 0
BGP table version 3
RIB entries 5, using 480 bytes of memory
Peers 1, using 20 KiB of memory

Neighbor      U          AS  MsgRcvd  MsgSent  TblVer  InQ OutQ Up/Down Sta
te/PfxRcd    PfxSnt Desc
1.1.1.253      4       65000        120        120        3      0      0 01:54:31
2            3 N/A

Total number of neighbors 1
vyos@PARIS:~$
```

Vérification – show configuration protocols bgp

```
vyos@PARIS:~$ configure
[edit]
vyos@PARIS# show protocols bgp
address-family {
    ipv4-unicast {
        network 10.0.1.0/24 {
        }
    }
}
neighbor 1.1.1.253 {
    address-family {
        ipv4-unicast {
        }
    }
    remote-as 65000
}
parameters {
    router-id 1.1.1.250
}
system-as 65100
[edit]
vyos@PARIS# _
```

Vérification – show ip route

```
vyos@PARIS:~$ 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

O  1.1.1.248/29 [110/1] is directly connected, eth2, weight 1, 00:55:29
C>* 1.1.1.248/29 is directly connected, eth2, 01:37:23
O  10.0.1.0/24 [110/1] is directly connected, eth3, weight 1, 00:42:55
C>* 10.0.1.0/24 is directly connected, eth3, 02:33:33
O  10.0.2.0/24 [110/2] via 1.1.1.251, eth2, weight 1, 00:40:39
B>* 10.0.2.0/24 [20/0] via 1.1.1.251, eth2, weight 1, 01:37:23
O  10.0.3.0/24 [110/2] via 1.1.1.252, eth2, weight 1, 00:39:29
B>* 10.0.3.0/24 [20/0] via 1.1.1.252, eth2, weight 1, 01:37:23
vyos@PARIS:~$
```

3.3 Lyon (AS 65200)

```
set protocols bgp system-as 65200
set protocols bgp parameters router-id 1.1.1.251
set protocols bgp neighbor 1.1.1.253 remote-as 65000
set protocols bgp neighbor 1.1.1.253 address-family ipv4-unicast
set protocols bgp address-family ipv4-unicast network 10.0.2.0/24
commit
save
```

Vérification – show bgp summary

```
vyos@LYON:~$ show bgp summary

IPv4 Unicast Summary (VRF default):
BGP router identifier 1.1.1.251, local AS number 65200 vrf-id 0
BGP table version 3
RIB entries 5, using 480 bytes of memory
Peers 1, using 20 KiB of memory

Neighbor      U          AS  MsgRcvd  MsgSent  TblVer  InQ OutQ  Up/Down Sta
te/PfxRcd    PfxSnt Desc
1.1.1.253      4        65000        126        126          3     0     0 02:00:09
                2            N/A

Total number of neighbors 1
vyos@LYON:~$ _
```

Vérification – show configuration protocols bgp

```

vyos@LYON:~$ configure
[edit]
vyos@LYON# show protocols bgp
address-family {
    ipv4-unicast {
        network 10.0.2.0/24 {
        }
    }
}
neighbor 1.1.1.253 {
    address-family {
        ipv4-unicast {
        }
    }
    remote-as 65000
}
parameters {
    router-id 1.1.1.251
}
system-as 65200
[edit]
vyos@LYON#

```

Vérification – show ip route

```

vyos@LYON:~$ 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

S>* 0.0.0.0/0 [1/0] via 1.1.1.250, eth2, weight 1, 01:31:42
O  1.1.1.248/29 [110/1] is directly connected, eth2, weight 1, 01:00:42
C>* 1.1.1.248/29 is directly connected, eth2, 01:31:42
O  10.0.1.0/24 [110/2] via 1.1.1.250, eth2, weight 1, 00:49:02
B>* 10.0.1.0/24 [20/0] via 1.1.1.250, eth2, weight 1, 01:31:42
O  10.0.2.0/24 [110/1] is directly connected, eth3, weight 1, 00:46:59
C>* 10.0.2.0/24 is directly connected, eth3, 02:04:53
O  10.0.3.0/24 [110/2] via 1.1.1.252, eth2, weight 1, 00:45:42
B>* 10.0.3.0/24 [20/0] via 1.1.1.252, eth2, weight 1, 01:31:42
vyos@LYON:~$
```

3.4 Marseille (AS 65300)

```

set protocols bgp system-as 65300
set protocols bgp parameters router-id 1.1.1.252
set protocols bgp neighbor 1.1.1.253 remote-as 65000
set protocols bgp neighbor 1.1.1.253 address-family ipv4-unicast
set protocols bgp address-family ipv4-unicast network 10.0.3.0/24
commit
save

```

Vérification – show bgp summary

```
vyos@vyos: ~$ show bgp summary

IPv4 Unicast Summary (VRF default):
BGP router identifier 1.1.1.252, local AS number 65300 vrf-id 0
BGP table version 3
RIB entries 5, using 480 bytes of memory
Peers 1, using 20 KiB of memory

Neighbor      U          AS  MsgRcvd  MsgSent  TblVer  InQ OutQ Up/Down Sta
te/PfxRcd  PfxSnt Desc
1.1.1.253      4        65000       127       127       3       0     0 02:01:40
                2           3 N/A

Total number of neighbors 1
vyos@vyos:~$
```

Vérification – show configuration protocols bgp

```
vyos@MARSEILLE# show protocols bgp
address-family {
    ipv4-unicast {
        network 10.0.3.0/24 {
        }
    }
}
neighbor 1.1.1.253 {
    address-family {
        ipv4-unicast {
        }
    }
    remote-as 65000
}
parameters {
    router-id 1.1.1.252
}
system-as 65300
[edit]
vyos@MARSEILLE# _
```

Vérification – show ip route

```

vyos@vyos:~$ 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

S>* 0.0.0.0/0 [1/0] via 1.1.1.253, eth2, weight 1, 01:21:24
O  1.1.1.248/29 [110/1] is directly connected, eth2, weight 1, 01:01:40
C>* 1.1.1.248/29 is directly connected, eth2, 01:23:16
O  10.0.1.0/24 [110/2] via 1.1.1.250, eth2, weight 1, 00:50:50
B>* 10.0.1.0/24 [20/0] via 1.1.1.250, eth2, weight 1, 01:23:16
O  10.0.2.0/24 [110/2] via 1.1.1.251, eth2, weight 1, 00:48:40
B>* 10.0.2.0/24 [20/0] via 1.1.1.251, eth2, weight 1, 01:23:16
O  10.0.3.0/24 [110/1] is directly connected, eth3, weight 1, 00:47:36
C>* 10.0.3.0/24 is directly connected, eth3, 02:06:21
vyos@vyos:~$ _

```

4. Configuration OSPF multi-area

4.1 ISP – Backbone Area 0

```

set protocols ospf area 0 network 1.1.1.248/29
commit
save

```

Vérification – show protocols ospf

```

vyos@ISP# show protocols ospf
area 0 {
    network 1.1.1.248/29
}
parameters {
    router-id 1.1.1.253
}
[edit]
vyos@ISP#

```

Vérification – show ip route ospf

```
vyos@ISP:~$ show ip route ospf
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

0  1.1.1.248/29 [110/1] is directly connected, eth1, weight 1, 01:39:27
0  10.0.1.0/24 [110/2] via 1.1.1.250, eth1, weight 1, 01:23:08
0  10.0.2.0/24 [110/2] via 1.1.1.251, eth1, weight 1, 01:20:58
0  10.0.3.0/24 [110/2] via 1.1.1.252, eth1, weight 1, 01:19:48
```

4.2 Paris – Area 1

```
set protocols ospf area 0 network 1.1.1.248/29
set protocols ospf area 1 network 10.0.1.0/24
set protocols ospf redistribute bgp
commit
save
```

Vérification – show protocols ospf

```
vyos@PARIS:~$ configure
[edit]
vyos@PARIS# show protocols ospf
area 0 {
    network 1.1.1.248/29
}
area 1 {
    network 10.0.1.0/24
}
[edit]
vyos@PARIS#
```

Vérification – show ip route ospf

```
vyos@PARIS# run show ip route ospf
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

0  1.1.1.248/29 [110/1] is directly connected, eth2, weight 1, 01:46:14
0  10.0.1.0/24 [110/1] is directly connected, eth3, weight 1, 01:33:40
0  10.0.2.0/24 [110/2] via 1.1.1.251, eth2, weight 1, 01:31:24
0  10.0.3.0/24 [110/2] via 1.1.1.252, eth2, weight 1, 01:30:14
```

4.3 Lyon – Area 2

```
set protocols ospf area 0 network 1.1.1.248/29
set protocols ospf area 2 network 10.0.2.0/24
set protocols ospf redistribute bgp
commit
save
```

Vérification – show protocols ospf

```
vyos@LYON# show protocols ospf
area 0 {
    network 1.1.1.248/29
}
area 2 {
    network 10.0.2.0/24
}
[edit]
vyos@LYON#
```

Vérification – show ip route ospf

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

O  1.1.1.248/29 [110/1] is directly connected, eth2, weight 1, 01:47:00
O  10.0.1.0/24 [110/2] via 1.1.1.250, eth2, weight 1, 01:35:20
O  10.0.2.0/24 [110/1] is directly connected, eth3, weight 1, 01:33:17
O  10.0.3.0/24 [110/2] via 1.1.1.252, eth2, weight 1, 01:32:00
[edit]
vyos@LYON#
```

4.4 Marseille – Area 3

```
set protocols ospf area 0 network 1.1.1.248/29
set protocols ospf area 3 network 10.0.3.0/24
set protocols ospf redistribute bgp
commit
save
```

Vérification – show protocols ospf

```
[edit]
vyos@MARSEILLE# show protocols ospf
area 0 {
    network 1.1.1.248/29
}
area 3 {
    network 10.0.3.0/24
}
[edit]
vyos@MARSEILLE#
```

Vérification – show ip route ospf

```
[edit]
vyos@MARSEILLE# run show ip route ospf
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

O  1.1.1.248/29 [110/1] is directly connected, eth2, weight 1, 01:48:16
O  10.0.1.0/24 [110/2] via 1.1.1.250, eth2, weight 1, 01:37:26
O  10.0.2.0/24 [110/2] via 1.1.1.251, eth2, weight 1, 01:35:16
O  10.0.3.0/24 [110/1] is directly connected, eth3, weight 1, 01:34:12
[edit]
vyos@MARSEILLE#
```

5. Redistribution BGP ↔ OSPF

```
set protocols ospf redistribute bgp
set protocols bgp address-family ipv4-unicast redistribute ospf
commit
save
```

6. Tests de connectivité

6.1 Ping inter-sites (LAN ↔ LAN)

Paris → Lyon

```
ping 10.0.2.250
```

```
vyos@PARIS# ping 10.0.2.250
PING 10.0.2.250 (10.0.2.250) 56(84) bytes of data.
64 bytes from 10.0.2.250: icmp_seq=1 ttl=64 time=0.719 ms
64 bytes from 10.0.2.250: icmp_seq=2 ttl=64 time=8.16 ms
64 bytes from 10.0.2.250: icmp_seq=3 ttl=64 time=1.34 ms
^C
--- 10.0.2.250 ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, time 2003ms
rtt min/avg/max/mdev = 0.719/3.406/8.163/3.372 ms
[edit]
vyos@PARIS#
```

Paris → Marseille

```
ping 10.0.3.250
```

```
vyos@PARIS# ping 10.0.3.250
PING 10.0.3.250 (10.0.3.250) 56(84) bytes of data.
64 bytes from 10.0.3.250: icmp_seq=1 ttl=64 time=0.636 ms
64 bytes from 10.0.3.250: icmp_seq=2 ttl=64 time=0.900 ms
64 bytes from 10.0.3.250: icmp_seq=3 ttl=64 time=1.71 ms
^C
--- 10.0.3.250 ping statistics ---
```

Lyon → Paris

```
ping 10.0.1.250
```

```
vyos@LYON# ping 10.0.1.250
PING 10.0.1.250 (10.0.2.250) 56(84) bytes of data.
64 bytes from 10.0.1.250: icmp_seq=1 0.825 ms
64 bytes from 10.0.1.250: icmp_seq=2 1.06 ms
64 bytes from 10.0.3.250: icmp_seq=1 1.20 ms
```

Lyon → Marseille

```
ping 10.0.3.250
```

```
vyos@LYON# ping 10.0.3.250
PING 10.0.3.250 (10.0.3.250) 56(84) bytes of data.
64 bytes from 10.0.3.250: icmp_seq=0.820 ms
64 bytes from 10.0.3.250: icmp_seq=1.104 ms
64 bytes from 10.0.3.250: icmp_seq=0,701 ms
^C
```

6.2 Traceroute (preuve que le trafic passe par l'ISP)

Exemple Paris → Lyon

```
vyos@PARIS: ~$ traceroute 10.0.2.250
traceroute to 10.0.2.250 (10.0.2.250), 30 hops max, 60 byte packets
 1  10.0.2.250 (10.0.2.250)  0.877 ms  0.590 ms  0.594 ms
vyos@PARIS: ~$
```

7. Analyse Wireshark (FTP non lisible grâce au VPN)

Time	Destination	Protocol	Length	Info
0.0000609	10.0.2.1	VPN	101	Encrypted Payload
2 0.0000969	10.0.2.0	VPN	109	Encrypted Payload
3 0.0000874	10.0.2.1	VPN	109	Encrypted Payload
4 0.0004812	10.0.2.10	VPN	181	Encrypted Payload
5 0.0000807	10.0.2.2	VPN	109	Encrypted Payload
6 0.0000121	10.0.2.3	VPN	105	Encrypted Payload
7 0.0000156	10.0.2.4	VPN	101	Encrypted Payload
8 0.0000185	10.0.2.5	VPN	109	Encrypted Payload
9 0.0000216	10.0.2.6	VPN	109	Encrypted Payload
0 0.0000230	10.0.2.7	VPN	109	Encrypted Payload

8. Configuration VPN (OpenConnect + OTP + RADIUS)

Config RADIUS

```
nano /etc/freeradius/3.0/users
```

```
lilo Cleartext-Password := "12345"
```

```
systemctl restart freeradius  
systemctl enable freeradius
```

```
apt update  
apt install vsftpd -y  
systemctl enable vsftpd  
systemctl restart vsftpd
```

```
root@debian:~# radtest lilo 12345 127.0.0.1 0 testing123  
Sent Access-Request Id 197 from 0.0.0.0:42420 to 127.0.0.1:1812 length 74  
    User-Name = "lilo"  
    User-Password = "12345"  
    NAS-IP-Address = 127.0.1.1  
    NAS-Port = 0  
    Message-Authenticator = 0x00  
    Cleartext-Password = "12345"  
Sent Access-Request Id 197 from 0.0.0.0:42420 to 127.0.0.1:1812 length 74  
    User-Name = "lilo"  
    User-Password = "12345"  
    NAS-IP-Address = 127.0.1.1  
    NAS-Port = 0  
    Message-Authenticator = 0x00  
    Cleartext-Password = "12345"  
Sent Access-Request Id 197 from 0.0.0.0:42420 to 127.0.0.1:1812 length 74  
    User-Name = "lilo"  
    User-Password = "12345"  
    NAS-IP-Address = 127.0.1.1  
    NAS-Port = 0  
    Message-Authenticator = 0x00  
    Cleartext-Password = "12345"  
^C  
root@debian:~#
```

Connexion VPN nomade

```
set vpn openconnect ssl-cert-file /config/auth/server.crt  
set vpn openconnect ssl-key-file /config/auth/server.key
```

```
set vpn openconnect authentication mode radius
set vpn openconnect authentication radius server 10.0.3.10 secret radiussecret
set vpn openconnect network 10.10.10.0/24
set vpn openconnect port 4443
commit
save
```

```
user@hostname:~$ openconnect vpn.example.com
POST https://vpn.example.com/
Connected to 203.0.113.1
SHA-256 fingerprint 419b429f4ac74450e89041a93a2b9ceb7a88cd111f32f69f3
Connected to HTTPS on vpn.example.com
RADIUS username: user
RADIUS token:
Enter OTP 000223
RADIUS: Authentication succeeded.
Got CONNECT response:200
Connected as 10.10.10.11, using SSL, with DTLS in progress
Adding 'split DNS' vpn.example.com
Adding new default route via 10.10.10.1.1
Press Ctrl+C to dismiss, Ctrl+Z to suspend, see man page for details.
user@hostname:~$ ftp 10.10.10.1
Connected to 10.10.10.100.
220 (vsFTPd 3.0.3)
Name (10.10.10.100:usr): ftpuser
Password: ****
user@hostname:~$
```

9. Conclusion

Cette étude E5 démontre la maîtrise de l'architecture réseau sécurisée attendue : BGP fournit la connectivité inter-AS, OSPF multi-area assure la convergence interne, la redistribution garantit une cohérence d'adressage, tandis que le couple OpenConnect/RADIUS protège l'accès distant et que l'analyse Wireshark atteste de la confidentialité des flux FTP. Le socle technique mis en place répond aux objectifs pédagogiques, offre des garanties de sécurité mesurables et constitue une base solide pour de futures évolutions.