Projet IP MPLS: Multiprotocol Label Switching

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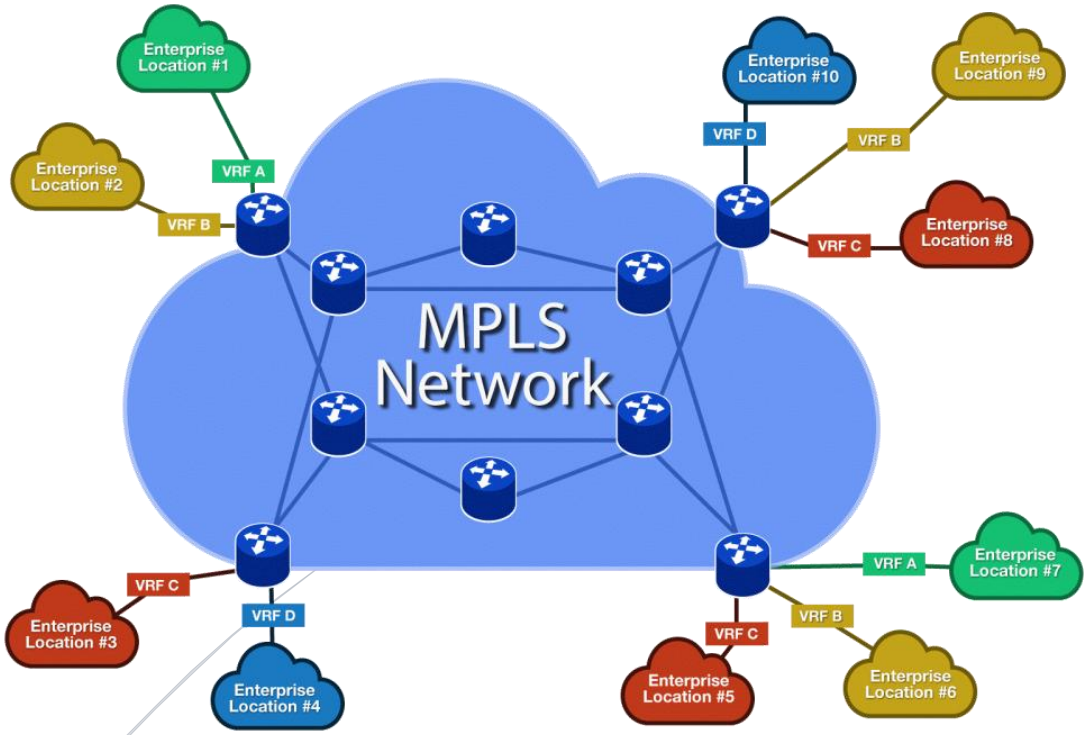

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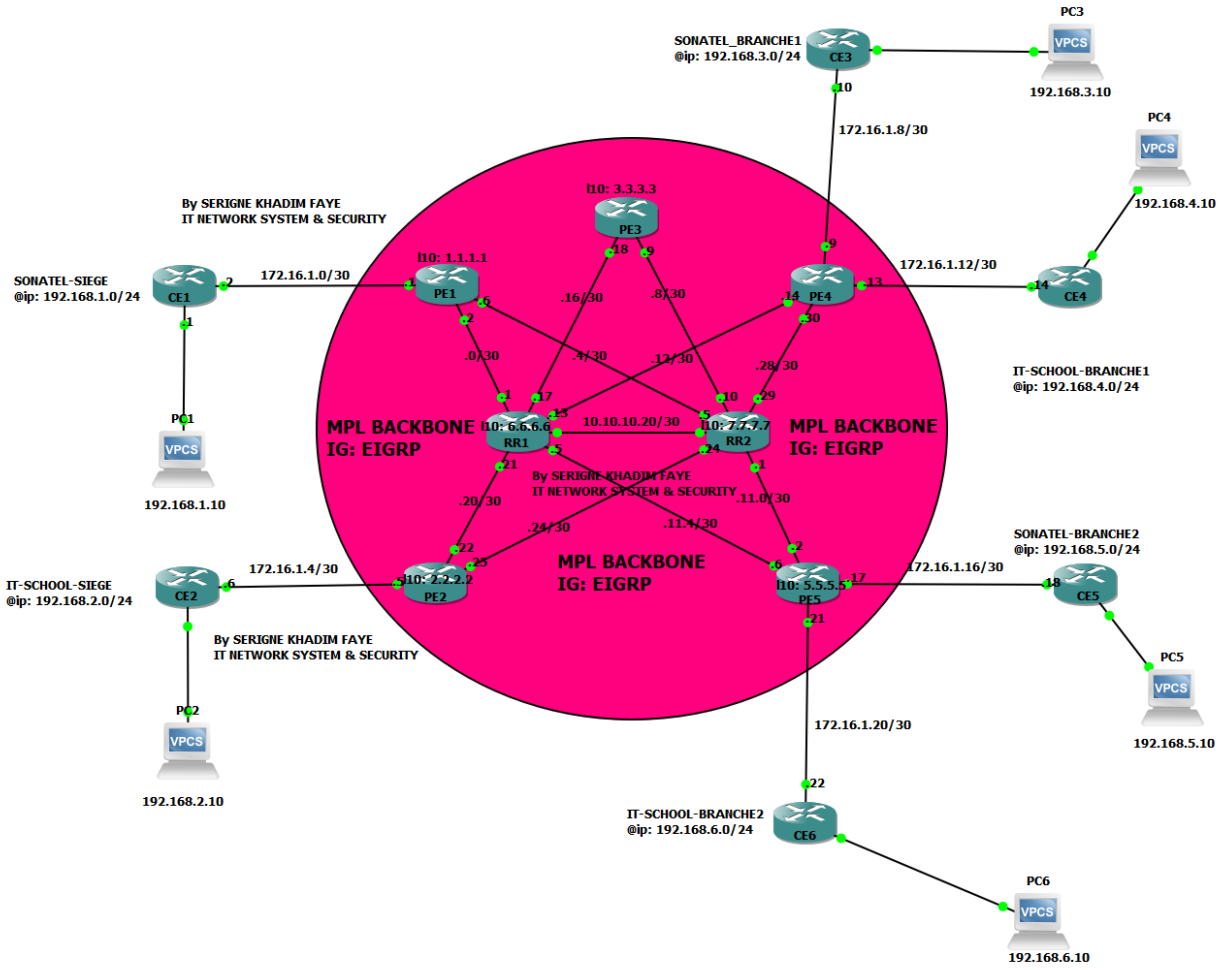
Introduction

Dans un contexte où la demande de connectivité et de fiabilité des réseaux ne cesse de croître, la mise en place d'une architecture de backbone IP/MPLS devient essentielle. Ce projet vise à concevoir et à déployer un backbone IP/MPLS basé sur les technologies CISCO, permettant une interconnexion efficace entre différents sites d'entreprises. L'architecture sera conçue de manière à faciliter la réflexion des routes à travers un Route Reflector (RR) et à assurer une communication fluide entre les différentes entités du réseau. L'objectif final est de garantir une communication transparente et sécurisée entre les entreprises partenaires.

Présentation de l'Architecture IP/MPLS



L'architecture IP/MPLS (Multi-Protocol Label Switching) proposée est conçue pour offrir une connectivité fiable et efficace entre plusieurs sites d'entreprises, en tirant parti de la technologie CISCO. Cette architecture repose sur les éléments suivants :

- **Backbone IP/MPLS**

Le backbone est constitué de cinq routeurs PE (Provider Edge), sans routeur P (Provider), permettant ainsi une interconnexion directe entre les équipements des fournisseurs de services et les équipements des clients.

- **Route Reflector (RR)**

Un Route Reflector (RR) est intégré pour faciliter le routage au sein du backbone. Ce dispositif réfléchit les informations de routage entre les routeurs PE, permettant ainsi une meilleure gestion des routes et une réduction de la charge de traitement sur les routeurs.

- **Redondance et Scalabilité**

Un Route Reflector secondaire sera ajouté pour assurer la redondance et garantir la continuité du service en cas de défaillance d'un RR. Cela permettra également d'augmenter la scalabilité du réseau, facilitant l'ajout de nouveaux sites ou entreprises sans nécessiter de modifications majeures de l'architecture existante.

- **Protocoles de Routage**

Le protocole IGP qui sera utilisé est **EIGRP (Enhanced Interior Gateway Routing Protocol)** pour garantir le routage interne. En parallèle, le protocole **BGP (Border Gateway Protocol)** sera utilisé pour échanger des informations de routage entre les routeurs PE et CE, permettant ainsi une communication efficace entre les différents sites des entreprises partenaires.

Plan d'adressage (Voir figure)

```
PE1#show ip interface brief
Interface              IP-Address      OK? Method Status                Proto
FastEthernet0/0        unassigned      YES unset  administratively down down
Ethernet1/0            172.16.1.1      YES manual up                    up
Ethernet1/1            10.10.10.2      YES manual up                    up
Ethernet1/2            10.10.10.6      YES manual up                    up
Ethernet1/3            unassigned      YES unset  administratively down down
Ethernet1/4            unassigned      YES unset  administratively down down
Ethernet1/5            unassigned      YES unset  administratively down down
Ethernet1/6            unassigned      YES unset  administratively down down
Ethernet1/7            unassigned      YES unset  administratively down down
GigabitEthernet2/0     unassigned      YES unset  administratively down down
GigabitEthernet3/0     unassigned      YES unset  administratively down down
GigabitEthernet4/0     unassigned      YES unset  administratively down down
GigabitEthernet5/0     unassigned      YES unset  administratively down down
Loopback10             1.1.1.1         YES manual up                    up
PE1#
```

```
RR1#show ip interface brief
Interface              IP-Address      OK? Method Status                Proto
FastEthernet0/0        unassigned      YES unset  administratively down down
Ethernet1/0            10.10.10.17     YES manual up                    up
Ethernet1/1            10.10.10.1      YES manual up                    up
Ethernet1/2            10.10.10.13     YES manual up                    up
Ethernet1/3            10.10.10.21     YES manual up                    up
Ethernet1/4            unassigned      YES unset  administratively down down
Ethernet1/5            10.10.11.5      YES manual up                    up
Ethernet1/6            unassigned      YES unset  administratively down down
Ethernet1/7            unassigned      YES unset  administratively down down
GigabitEthernet2/0     unassigned      YES unset  administratively down down
GigabitEthernet3/0     unassigned      YES unset  administratively down down
GigabitEthernet4/0     unassigned      YES unset  administratively down down
GigabitEthernet5/0     unassigned      YES unset  administratively down down
Loopback10             6.6.6.6         YES manual up                    up
RR1#
```

Dans cette architecture IP/MPLS, nous allons utiliser **EIGRP** comme protocole de routage pour le backbone. La première étape consistera à configurer les interfaces des routeurs conformément au plan d'adressage défini, en veillant à respecter les sous-réseaux alloués. Une fois les interfaces configurées, nous procéderons à l'activation EIGRP sur chaque routeur PE, ainsi que sur le **Route Reflector** (**RR**).

- **Configuration des interfaces physique et virtuelles (loopback) de tous les routeurs.**

Exemple de configuration des interfaces sur PE1 :

```
# PE interfaces configuration
configure terminale
interface ethernet1/0
description ### Vers CE1 ###
ip address 172.16.1.1 255.255.255.252
no shutdown
exit
interface loopback 10
ip address 1.1.1.1 255.255.255.255
exit
```

```
interface ethernet1/1
description ### Vers RR1 ###
ip address 10.10.10.2 255.255.255.252
no shutdown
exit
interface ethernet1/2
description ### Vers RR2 ###
Ip address 10.10.10.6 255.255.255.252
no shutdown
end
write
```

Nous faire de même sur toutes les interfaces des PE et des deux RR en veillant sur le reste de l'adressage et des interfaces.

Test de vérification de la configuration des interfaces: show ip interfaces brief

```
PE1#show ip interface brief
Interface              IP-Address      OK? Method Status                Protocol
FastEthernet0/0        unassigned      YES NVRAM  administratively down down
Ethernet1/0            172.16.1.1      YES NVRAM  up                    up
Ethernet1/1            10.10.10.2      YES NVRAM  up                    up
Ethernet1/2            10.10.10.6      YES NVRAM  up                    up
Ethernet1/3            unassigned      YES NVRAM  administratively down down
Ethernet1/4            unassigned      YES NVRAM  administratively down down
Ethernet1/5            unassigned      YES NVRAM  administratively down down
Ethernet1/6            unassigned      YES NVRAM  administratively down down
Ethernet1/7            unassigned      YES NVRAM  administratively down down
GigabitEthernet2/0     unassigned      YES NVRAM  administratively down down
GigabitEthernet3/0     unassigned      YES NVRAM  administratively down down
GigabitEthernet4/0     unassigned      YES NVRAM  administratively down down
GigabitEthernet5/0     unassigned      YES NVRAM  administratively down down
Loopback10             1.1.1.1         YES NVRAM  up                    up
```

```
RR1#show ip interface brief
Interface              IP-Address      OK? Method Status                Protocol
FastEthernet0/0        unassigned      YES NVRAM  administratively down down
Ethernet1/0            10.10.10.17     YES NVRAM  up                    up
Ethernet1/1            10.10.10.1      YES NVRAM  up                    up
Ethernet1/2            10.10.10.13     YES NVRAM  up                    up
Ethernet1/3            10.10.10.21     YES NVRAM  up                    up
Ethernet1/4            unassigned      YES NVRAM  administratively down down
Ethernet1/5            10.10.11.5      YES NVRAM  up                    up
Ethernet1/6            unassigned      YES NVRAM  administratively down down
Ethernet1/7            unassigned      YES NVRAM  administratively down down
GigabitEthernet2/0     unassigned      YES NVRAM  administratively down down
GigabitEthernet3/0     unassigned      YES NVRAM  administratively down down
GigabitEthernet4/0     unassigned      YES NVRAM  administratively down down
GigabitEthernet5/0     unassigned      YES NVRAM  administratively down down
Loopback10             6.6.6.6         YES NVRAM  up                    up
```

- **Configuration IGP sur les routeurs PE**

Nous allons configurer un protocole de routage interne entre tous les routeurs PE constituant notre backbone pour prendre en charge LDP et BGP au sein du réseau du fournisseur. Nous pouvons configurer EIGRP.

Exemple de configuration du EIGRP sur PE1, PE2, RR1 et RR2

 # EIGRP sur PE1

```
configure terminale
router eigrp 1
 network 1.1.1.1 0.0.0.0
 network 10.10.10.0 0.0.0.3
 network 10.10.10.4 0.0.0.3
end
write
```

 # EIGRP sur PE2

```
router eigrp 1
 network 2.2.2.2 0.0.0.0
 network 10.10.10.20 0.0.0.3
 network 10.10.10.24 0.0.0.3
end
write
```

 # EIGRP sur RR1

```
router eigrp 1
 network 6.6.6.6 0.0.0.0
 network 10.10.10.0 0.0.0.3
 network 10.10.10.12 0.0.0.3
 network 10.10.10.16 0.0.0.3
 network 10.10.10.20 0.0.0.3
 network 10.10.10.28 0.0.0.3
 network 10.10.11.4 0.0.0.3
```

 # EIGRP sur RR2

```
router eigrp 1
 network 7.7.7.7 0.0.0.0
 network 10.10.10.4 0.0.0.3
 network 10.10.10.8 0.0.0.3
 network 10.10.10.24 0.0.0.3
 network 10.10.10.28 0.0.0.3
 network 10.10.11.0 0.0.0.3
```

- **Vérification de la configuration du IGP dans le backbone : show ip eigrp neighbors / show ip route eigrp | begin Gateway (sur RR1, RR2 et PE1)**

```
RR1#show ip eigrp neighbors
EIGRP-IPv4 Neighbors for AS(1)
H   Address                 Interface       Hold Uptime   SRTT   RTO  Q  Seq
                                            (sec)         (ms)       Cnt Num
2   10.10.10.14             Et1/2            14 00:11:47   14   150  0  43
3   10.10.10.22             Et1/3            12 00:14:34   62   372  0  60
1   10.10.10.18             Et1/0            12 00:14:34   85   510  0  67
4   10.10.11.6              Et1/5            13 00:14:52   97   582  0  21
0   10.10.10.2              Et1/1            10 00:25:37   67   402  0  82
RR1#
```

```
RR2#show ip eigrp neighbors
EIGRP-IPv4 Neighbors for AS(1)
H   Address                 Interface              Hold Uptime   SRTT   RTO  Q  Seq
                                                   (sec)         (ms)       Cnt Num
2   10.10.10.25             Et1/4                    11 00:11:19  173  1038  0  61
4   10.10.11.2              Et1/6                    12 00:13:45  614  3684  0  20
3   10.10.10.30             Et1/0                    13 00:27:32  143   858  0  44
1   10.10.10.9              Et1/1                    11 00:44:23  138   828  0  66
0   10.10.10.6              Et1/2                    14 00:54:28  120   720  0  81
RR2#
```

```
PE1#show ip eigrp neighbors
EIGRP-IPv4 Neighbors for AS(1)
H   Address                 Interface              Hold Uptime   SRTT   RTO  Q  Seq
                                                   (sec)         (ms)       Cnt Num
0   10.10.10.1              Et1/1                    11 00:27:53   73   438  0  138
1   10.10.10.5              Et1/2                    12 00:56:47   97   582  0  142
PE1#
```

Testons la connectivité au niveau du backbone en faisant un ping du RR1 vers tous les PE et du RR2 vers tous les PE.

A ce stade, nous pouvons conclure qu'il y'a une parfaite connectivite entre les équipements du backbone.

```
RR1#ping 1.1.1.1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 1.1.1.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 48/52/56 ms
RR1#ping 2.2.2.2
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 2.2.2.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 32/48/52 ms
RR1#ping 3.3.3.3
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 3.3.3.3, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 48/52/56 ms
RR1#ping 4.4.4.4
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 4.4.4.4, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 52/53/60 ms
RR1#ping 5.5.5.5
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 5.5.5.5, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 52/56/68 ms
RR1#ping 7.7.7.7
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 7.7.7.7, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 52/58/76 ms
RR1#
```

```
RR2#ping 1.1.1.1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 1.1.1.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 36/48/56 ms
RR2#ping 2.2.2.2
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 2.2.2.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 48/56/76 ms
RR2#ping 3.3.3.3
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 3.3.3.3, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 48/52/56 ms
RR2#ping 4.4.4.4
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 4.4.4.4, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 48/52/56 ms
RR2#ping 5.5.5.5
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 5.5.5.5, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 48/52/56 ms
RR2#ping 6.6.6
% Unrecognized host or address, or protocol not running.

RR2#ping 6.6.6.6
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 6.6.6.6, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 52/56/60 ms
RR2#
```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❖ **Conf du BGP et du MP-BGP sur les tous les PE (la configuration est la même)**

```
PE5#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
PE5(config)#router bgp 64501
PE5(config-router)#bgp log-neighbor-changes
PE5(config-router)#neighbor 6.6.6.6 remote-as 64501
PE5(config-router)#neighbor 6.6.6.6 update-source Loopback10
PE5(config-router)#address-family vpnv4
PE5(config-router-af)#neighbor 6.6.6.6 activate
PE5(config-router-af)#neighbor 6.6.6.6 send-community extended
PE5(config-router-af)#exit-address-family
PE5(config-router)#
PE5(config-router)#
PE5(config-router)#
PE5(config-router)#
PE5(config-router)#exit
PE5(config)#
PE5(config)#router bgp 64501
PE5(config-router)#bgp log-neighbor-changes
PE5(config-router)#neighbor 7.7.7.7 remote-as 64501
PE5(config-router)#neighbor 7.7.7.7 update-source Loopback10
PE5(config-router)#address-family vpnv4
PE5(config-router-af)#neighbor 7.7.7.7 activate
PE5(config-router-af)#neighbor 7.7.7.7 send-community extended
PE5(config-router-af)#exit-address-family
```

```
PE1#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
PE1(config)#router bgp 64501
PE1(config-router)#bgp log-neighbor-changes
PE1(config-router)#neighbor 6.6.6.6 remote-as 64501
PE1(config-router)#neighbor 6.6.6.6 update-source Loopback10
PE1(config-router)#address-family vpnv4
PE1(config-router-af)#neighbor 6.6.6.6 activate
PE1(config-router-af)#neighbor 6.6.6.6 send-community extended
PE1(config-router-af)#exit-address-family
PE1(config-router)#
PE1(config-router)#
PE1(config-router)#exit
PE1(config)#router bgp 64501
PE1(config-router)#bgp log-neighbor-changes
PE1(config-router)#neighbor 7.7.7.7 remote-as 64501
PE1(config-router)#neighbor 7.7.7.7 update-source Loopback10
PE1(config-router)#address-family vpnv4
PE1(config-router-af)#neighbor 7.7.7.7 activate
PE1(config-router-af)#neighbor 7.7.7.7 send-community extended
PE1(config-router-af)#exit-address-family
```

Apres avoir configurer le BGP et le MP-BGP sur les PE, nous allons configurer le BGP sur le RR1 et le RR2.

```
RR1(config)#router bgp 64501
RR1(config-router)#bgp log-neighbor-changes
RR1(config-router)#neighbor 1.1.1.1 remote-as 64501
RR1(config-router)#neighbor 1.1.1.1 route-reflector-client
RR1(config-router)#neighbor 1.1.1.1 update-source Loopback10
RR1(config-router)#
RR1(config-router)#
RR1(config-router)#
*Oct 11 01:01:24.991: %BGP-5-ADJCHANGE: neighbor 1.1.1.1 Up
RR1(config-router)#neighbor 2.2.2.2 remote-as 64501
RR1(config-router)#neighbor 2.2.2.2 route-reflector-client
RR1(config-router)#neighbor 2.2.2.2 update-source Loopback10
RR1(config-router)#
RR1(config-router)#
RR1(config-router)#neighbor 3.3.3.3 remote-as 64501
RR1(config-router)#neighbor 3.3.3.3 route-reflector-client
RR1(config-router)#neighbor 3.3.3.3 update-source Loopback10
RR1(config-router)#
RR1(config-router)#
RR1(config-router)#
*Oct 11 01:01:35.295: %BGP-5-ADJCHANGE: neighbor 3.3.3.3 Up
RR1(config-router)#
*Oct 11 01:01:37.523: %BGP-5-ADJCHANGE: neighbor 2.2.2.2 Up
RR1(config-router)#neighbor 4.4.4.4 remote-as 64501
RR1(config-router)#neighbor 4.4.4.4 route-reflector-client
RR1(config-router)#neighbor 4.4.4.4 update-source Loopback10
RR1(config-router)#
RR1(config-router)#
RR1(config-router)#neighbor 5.5.5.5 remote-as 64501
RR1(config-router)#neighbor 5.5.5.5 route-reflector-client
RR1(config-router)#neighbor 5.5.5.5 update-source Loopback10
```

```
RR2(config)#router bgp 64501
RR2(config-router)#bgp log-neighbor-changes
RR2(config-router)#neighbor 1.1.1.1 remote-as 64501
RR2(config-router)#neighbor 1.1.1.1 route-reflector-client
RR2(config-router)#neighbor 1.1.1.1 update-source Loopback10
RR2(config-router)#neighbor 2.2.2.2 remote-as 64501
RR2(config-router)#neighbor 2.2.2.2 route-reflector-client
RR2(config-router)#neighbor 2.2.2.2 update-source Loopback10
RR2(config-router)#
*Oct 11 01:01:35.035: %BGP-5-ADJCHANGE: neighbor 1.1.1.1 Up
RR2(config-router)#neighbor 3.3.3.3 remote-as 64501
RR2(config-router)#neighbor 3.3.3.3 route-reflector-client
RR2(config-router)#neighbor 3.3.3.3 update-source Loopback10
RR2(config-router)#
*Oct 11 01:01:39.699: %BGP-5-ADJCHANGE: neighbor 2.2.2.2 Up
*Oct 11 01:01:40.079: %BGP-5-ADJCHANGE: neighbor 3.3.3.3 Up
RR2(config-router)#neighbor 4.4.4.4 remote-as 64501
RR2(config-router)#neighbor 4.4.4.4 route-reflector-client
RR2(config-router)#neighbor 4.4.4.4 update-source Loopback10
RR2(config-router)#
*Oct 11 01:01:43.331: %BGP-5-ADJCHANGE: neighbor 4.4.4.4 Up
RR2(config-router)#neighbor 5.5.5.5 remote-as 64501
RR2(config-router)#neighbor 5.5.5.5 route-reflector-client
RR2(config-router)#neighbor 5.5.5.5 update-source Loopback10
RR2(config-router)#
*Oct 11 01:01:54.263: %BGP-5-ADJCHANGE: neighbor 5.5.5.5 Up
RR2(config-router)#
```

Vérifions si les sessions BGP sont bien établies entre les PE et les deux RR.

Show ip bgp summary sur RR1 et RR2, PE1 et PE2

```
RR1#sh ip bgp summary
BGP router identifier 6.6.6.6, local AS number 64501
BGP table version is 1, main routing table version 1

Neighbor        V           AS MsgRcvd MsgSent   TblVer  InQ OutQ Up/Down  State/PfxRcd
1.1.1.1         4        64501       5       5        1    0    0 00:02:16        0
2.2.2.2         4        64501       4       5        1    0    0 00:02:04        0
3.3.3.3         4        64501       4       5        1    0    0 00:02:06        0
4.4.4.4         4        64501       5       5        1    0    0 00:01:53        0
5.5.5.5         4        64501       4       5        1    0    0 00:01:48        0
RR1#
```

```
RR2#sh ip bgp summary
BGP router identifier 7.7.7.7, local AS number 64501
BGP table version is 1, main routing table version 1

Neighbor        V           AS MsgRcvd MsgSent   TblVer  InQ OutQ Up/Down  State/PfxRcd
1.1.1.1         4        64501       4       4        1    0    0 00:01:14        0
2.2.2.2         4        64501       4       4        1    0    0 00:01:10        0
3.3.3.3         4        64501       4       4        1    0    0 00:01:09        0
4.4.4.4         4        64501       3       4        1    0    0 00:01:06        0
5.5.5.5         4        64501       4       4        1    0    0 00:00:55        0
RR2#
```

```
PE1#show ip bgp summary
BGP router identifier 1.1.1.1, local AS number 64501
BGP table version is 1, main routing table version 1

Neighbor        V           AS MsgRcvd MsgSent   TblVer  InQ OutQ Up/Down  State/PfxRcd
6.6.6.6         4        64501       7       6        1    0    0 00:03:56        0
7.7.7.7         4        64501       6       7        1    0    0 00:02:59        0
PE1#
```

```
PE2#show ip bgp summary
BGP router identifier 2.2.2.2, local AS number 64501
BGP table version is 1, main routing table version 1

Neighbor        V           AS MsgRcvd MsgSent   TblVer  InQ OutQ Up/Down  State/PfxRcd
6.6.6.6         4        64501       7       6        1    0    0 00:03:49        0
7.7.7.7         4        64501       6       6        1    0    0 00:03:01        0
PE2#
```

Les sessions BGP sont bien montées.

- **Configuration de BGP sur les routeurs clients (CE)**

Configurons le protocole BGP entre les routeurs CE et PE. Les numéros BGP AS sur chaque site client doivent être uniques et différents de l'ASN du fournisseur.

ASN BACKBONE: 64501

ASN SONATEL-SIEGE: 64401

ASN-SONATEL-BRANCHE1: 64402

ASN-SONATEL-BRANCHE2: 64403

ASN IT-SCHOOL-SIEGE: 64405

ASN IT-SCHOOL-BRANCHE1: 64406

ASN IT-SCHOOL-BRANCHE2: 64407

```
CE1(config)#router bgp 64401
CE1(config-router)#network 192.168.1.0 mask 255.255.255.0
CE1(config-router)#neighbor 172.16.1.1 remote-as 64501
CE1(config-router)#no auto-summary
CE1(config-router)#
CE1(config-router)#
CE1(config-router)#
```

```
CE2(config)#router bgp 64405
CE2(config-router)#network 192.168.2.0 mask 255.255.255.0
CE2(config-router)#neighbor 172.16.1.5 remote-as 64501
CE2(config-router)#no auto-summary
CE2(config-router)#
CE2(config-router)#
```

Verification: show running-config | section bgp

```
CE1#show running-config | section bgp
router bgp 64401
 bgp log-neighbor-changes
 network 192.168.1.0
 neighbor 172.16.1.1 remote-as 64501
CE1#
```

```
CE6#sh running-config | section bgp
router bgp 64407
 bgp log-neighbor-changes
 network 192.168.6.0
 neighbor 172.16.1.21 remote-as 64501
CE6#wr
Building configuration...
[OK]
CE6#
```

- **Activer MPLS sur les PE**

Nous devons activer MPLS dans le réseau d'un fournisseur. Les données des clients sont ensuite commutées dans le réseau MPLS sur la base de l'étiquette externe (LSP).

Il ne faut activer MPLS que sur les interfaces PE sur le backbone.

```
PE4(config)#do show cdp neighbors
Capability Codes: R - Router, T - Trans Bridge, B - Source Route Bridge
                  S - Switch, H - Host, I - IGMP, r - Repeater, P - Phone,
                  D - Remote, C - CVTA, M - Two-port Mac Relay

Device ID        Local Intrfce     Holdtme    Capability  Platform  Port ID
RR1              Eth 1/2           130              R    7206VXR   Eth 1/2
CE4              Eth 1/3           137              R    7206VXR   Eth 1/3
RR2              Eth 1/0           139              R    7206VXR   Eth 1/0
CE3              Eth 1/1           134              R    7206VXR   Eth 1/1
PE4(config)#in
PE4(config)#interface Eth 1/2
PE4(config-if)#mp
PE4(config-if)#mpls ip
PE4(config-if)#interface Eth 1/0
PE4(config-if)#mpls ip
```

Verification: show mpls ldp neighbor / show mpls forwarding-table

```
PE1#show mpls ldp neighbor
    Peer LDP Ident: 6.6.6.6:0; Local LDP Ident 1.1.1.1:0
        TCP connection: 6.6.6.6.47238 - 1.1.1.1.646
        State: Oper; Msgs sent/rcvd: 26/26; Downstream
        Up time: 00:04:47
        LDP discovery sources:
          Ethernet1/1, Src IP addr: 10.10.10.1
        Addresses bound to peer LDP Ident:
          10.10.10.17     10.10.10.1      10.10.10.13     10.10.10.21
          10.10.11.5      6.6.6.6
    Peer LDP Ident: 7.7.7.7:0; Local LDP Ident 1.1.1.1:0
        TCP connection: 7.7.7.7.18674 - 1.1.1.1.646
        State: Oper; Msgs sent/rcvd: 25/25; Downstream
        Up time: 00:04:08
        LDP discovery sources:
          Ethernet1/2, Src IP addr: 10.10.10.5
        Addresses bound to peer LDP Ident:
          10.10.10.29     10.10.10.10     10.10.10.5      10.10.10.26
          10.10.11.1      7.7.7.7
```

```
PE1#show mpls forwarding-table
Local      Outgoing   Prefix           Bytes Label   Outgoing   Next Hop
Label      Label      or Tunnel Id     Switched      interface
16         17         2.2.2.2/32       0             Et1/1      10.10.10.1
           17         2.2.2.2/32       0             Et1/2      10.10.10.5
17         19         4.4.4.4/32       0             Et1/1      10.10.10.1
           19         4.4.4.4/32       0             Et1/2      10.10.10.5
18         20         5.5.5.5/32       0             Et1/1      10.10.10.1
           20         5.5.5.5/32       0             Et1/2      10.10.10.5
19         18         3.3.3.3/32       0             Et1/1      10.10.10.1
           18         3.3.3.3/32       0             Et1/2      10.10.10.5
20         Pop Label  10.10.11.4/30    0             Et1/1      10.10.10.1
21         Pop Label  10.10.10.12/30   0             Et1/1      10.10.10.1
22         Pop Label  10.10.10.20/30   0             Et1/1      10.10.10.1
23         Pop Label  10.10.10.16/30   0             Et1/1      10.10.10.1
24         Pop Label  6.6.6.6/32       0             Et1/1      10.10.10.1
25         Pop Label  7.7.7.7/32       0             Et1/2      10.10.10.5
26         Pop Label  10.10.10.8/30    0             Et1/2      10.10.10.5
27         Pop Label  10.10.10.24/30   0             Et1/2      10.10.10.5
28         Pop Label  10.10.10.28/30   0             Et1/2      10.10.10.5
29         Pop Label  10.10.11.0/30    0             Et1/2      10.10.10.5
PE1#
```

```
PE1#traceroute 5.5.5.5
Type escape sequence to abort.
Tracing the route to 5.5.5.5
VRF info: (vrf in name/id, vrf out name/id)
  1 10.10.10.1 [MPLS: Label 20 Exp 0] 28 msec
    10.10.10.5 [MPLS: Label 20 Exp 0] 32 msec
    10.10.10.1 [MPLS: Label 20 Exp 0] 48 msec
  2 10.10.11.2 56 msec
    10.10.11.6 52 msec
    10.10.11.2 72 msec
PE1#
```

- **Création et attribution des VRF et les appliquer sur les interfaces**

Les tables de transfert des clients sont séparées en utilisant le concept de table de routage et de transfert VPN (VRF) sur le routeur PE.

Une VRF est configurée sur le routeur PE pour chaque client. L'interface PE du routeur qui connecte le routeur CE au réseau MPLS du fournisseur est ensuite attribuée à la VRF client.

Un différenciateur d'itinéraire est ajouté sur le routeur PE au préfixe du client pour distinguer le même préfixe et le même masque dans un VRF différent. Les différentes VRF seront crées sur PE1 PE2, PE4 et PE5.

```
PE4#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
PE4(config)#
PE4(config)#ip vrf SONATEL
PE4(config-vrf)#rd 64501:1
PE4(config-vrf)#route-target both  64501:1
PE4(config-vrf)#
PE4(config-vrf)#
PE4(config-vrf)#interface Ethernet1/1
PE4(config-if)#description #### vers SONATEL###
PE4(config-if)#ip vrf forwarding SONATEL
% Interface Ethernet1/1 IPv4 disabled and address(es) removed due to enabling VRF SONATEL
PE4(config-if)#ip address 172.16.1.9 255.255.255.252
PE4(config-if)#
```

```
PE4(config)#ip vrf ITSCHOOL
PE4(config-vrf)#rd 64501:2
PE4(config-vrf)#route-target both  64501:2
PE4(config-vrf)#
PE4(config-vrf)#
PE4(config-vrf)#interface Ethernet1/3
PE4(config-if)#description #### vers ITSCHOOL###
PE4(config-if)#ip vrf forwarding ITSCHOOL
% Interface Ethernet1/3 IPv4 disabled and address(es) removed due to enabling VRF ITSCHOOL
PE4(config-if)#ip address 172.16.1.13 255.255.255.252
PE4(config-if)#end
PE4#
*Oct 11 01:57:19.647: %SYS-5-CONFIG_I: Configured from console by console
PE4#
```

```
PE5#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
PE5(config)#ip vrf SONATEL
PE5(config-vrf)#rd 64501:1
PE5(config-vrf)#route-target both  64501:1
PE5(config-vrf)#
PE5(config-vrf)#
PE5(config-vrf)#interface Ethernet1/0
PE5(config-if)#description #### vers SONATEL###
PE5(config-if)#ip vrf forwarding SONATEL
% Interface Ethernet1/0 IPv4 disabled and address(es) removed due to enab
PE5(config-if)#ip address 172.16.1.17 255.255.255.252
PE5(config-if)#end
PE5#
*Oct 11 02:12:31.803: %SYS-5-CONFIG_I: Configured from console by console
PE5#wr
Building configuration...
[OK]
PE5#
```

```
PE5#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
PE5(config)#ip vrf ITSCHOOL
PE5(config-vrf)#rd 64501:2
PE5(config-vrf)#route-target both  64501:2
PE5(config-vrf)#
PE5(config-vrf)#
PE5(config-vrf)#
PE5(config-vrf)#interface Ethernet1/1
PE5(config-if)#description #### vers ITSCHOOL###
PE5(config-if)#ip vrf forwarding ITSCHOOL
% Interface Ethernet1/1 IPv4 disabled and address(es) removed due to enabling VRF ITSCHOOL
PE5(config-if)#ip address 172.16.1.21 255.255.255.252
PE5(config-if)#end
PE5#
*Oct 11 02:13:48.787: %SYS-5-CONFIG_I: Configured from console by console
PE5#
```

Vérifions si les VRF sont bien crées avec les bonnes interfaces.

```
PE4#show ip vrf brief
  Name                             Default RD          Interfaces
  ITSCHOOL                         64501:2             Et1/3
  SONATEL                          64501:1             Et1/1
PE4#
```

```
PE5#show ip vrf brief
  Name                             Default RD          Interfaces
  ITSCHOOL                         64501:2             Et1/1
  SONATEL                          64501:1             Et1/0
PE5#
```

```
PE2#show ip vrf brief
  Name                             Default RD          Interfaces
  ITSCHOOL                         64501:2             Et1/0
PE2#
```

```
PE1#show ip vrf brief
  Name                             Default RD          Interfaces
  SONATEL                          64501:1             Et1/0
PE1#
```

❖ **Configurer eBGP vers les clients sur PE**

Nous allons à présent configurer BGP entre les routeurs des clients et ceux du fournisseur afin d'établir une session BGP avec les routeurs CE.

```
PE1(config)#router bgp 64501
PE1(config-router)#address-family ipv4 vrf SONATEL
PE1(config-router-af)#neighbor 172.16.1.2 remote-as 64401
PE1(config-router-af)#neighbor 172.16.1.2 activate
PE1(config-router-af)#exit-address-family
PE1(config-router)#
PE1(config-router)#
PE1(config-router)#
*Oct 11 02:23:20.443: %BGP-5-ADJCHANGE: neighbor 172.16.1.2 vpn vrf SONATEL Up
PE1(config-router)#
```

```
PE2#sh ip vrf brief
  Name                             Default RD          Interfaces
  ITSCHOOL                         64501:2             Et1/0
PE2#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
PE2(config)#router bgp 64501
PE2(config-router)#address-family ipv4 vrf ITSCHOOL
PE2(config-router-af)#neighbor 172.16.1.6 remote-as 64405
PE2(config-router-af)#neighbor 172.16.1.6 activate
PE2(config-router-af)#exit-address-family
PE2(config-router)#
*Oct 11 02:24:33.387: %BGP-5-ADJCHANGE: neighbor 172.16.1.6 vpn vrf ITSCHOOL Up
PE2(config-router)#
```

```
PE4(config)#router bgp 64501
PE4(config-router)#address-family ipv4 vrf SONATEL
PE4(config-router-af)#neighbor 172.16.1.10 remote-as 64402
PE4(config-router-af)#neighbor 172.16.1.10 activate
PE4(config-router-af)#exit-address-family
PE4(config-router)#
*Oct 11 02:12:26.947: %BGP-5-ADJCHANGE: neighbor 172.16.1.10 vpn vrf SONATEL Up
PE4(config-router)#
```

```
PE4(config)#router bgp 64501
PE4(config-router)#address-family ipv4 vrf ITSCHOOL
PE4(config-router-af)#neighbor 172.16.1.14 remote-as 64406
PE4(config-router-af)#neighbor 172.16.1.14 activate
PE4(config-router-af)#exit-address-family
PE4(config-router)#
*Oct 11 02:13:58.795: %BGP-5-ADJCHANGE: neighbor 172.16.1.14 vpn vrf ITSCHOOL Up
PE4(config-router)#
```

```
PE5#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
PE5(config)#router bgp 64501
PE5(config-router)#address-family ipv4 vrf SONATEL
PE5(config-router-af)#neighbor 172.16.1.18 remote-as 64403
PE5(config-router-af)#neighbor 172.16.1.18 activate
PE5(config-router-af)#exit-address-family
PE5(config-router)#
*Oct 11 02:29:49.807: %BGP-5-ADJCHANGE: neighbor 172.16.1.18 vpn vrf SONATEL Up
PE5(config-router)#
```

```
PE5(config)#router bgp 64501
PE5(config-router)#address-family ipv4 vrf ITSCHOOL
PE5(config-router-af)#neighbor 172.16.1.22 remote-as 64407
PE5(config-router-af)#neighbor 172.16.1.22 activate
PE5(config-router-af)#exit-address-family
PE5(config-router)#
*Oct 11 02:30:59.595: %BGP-5-ADJCHANGE: neighbor 172.16.1.22 vpn vrf ITSCHOOL Up
PE5(config-router)#
```

Test de verification: show mpl forwarding-table

```
PE4#show mpls forwarding-table
Local      Outgoing   Prefix           Bytes Label   Outgoing   Next Hop
Label      Label      or Tunnel Id     Switched      interface
16         16         1.1.1.1/32       0             Et1/2      10.10.10.13
           16         1.1.1.1/32       0             Et1/0      10.10.10.29
17         17         2.2.2.2/32       0             Et1/2      10.10.10.13
           17         2.2.2.2/32       0             Et1/0      10.10.10.29
18         18         3.3.3.3/32       0             Et1/2      10.10.10.13
           18         3.3.3.3/32       0             Et1/0      10.10.10.29
19         20         5.5.5.5/32       0             Et1/2      10.10.10.13
           20         5.5.5.5/32       0             Et1/0      10.10.10.29
20         Pop Label  6.6.6.6/32       0             Et1/2      10.10.10.13
21         Pop Label  7.7.7.7/32       0             Et1/0      10.10.10.29
22         Pop Label  10.10.10.0/30     0             Et1/2      10.10.10.13
23         Pop Label  10.10.10.4/30     0             Et1/0      10.10.10.29
24         Pop Label  10.10.10.8/30     0             Et1/0      10.10.10.29
25         Pop Label  10.10.10.16/30    0             Et1/2      10.10.10.13
26         Pop Label  10.10.10.20/30    0             Et1/2      10.10.10.13
27         Pop Label  10.10.10.24/30    0             Et1/0      10.10.10.29
28         Pop Label  10.10.11.0/30     0             Et1/0      10.10.10.29
29         Pop Label  10.10.11.4/30     0             Et1/2      10.10.10.13
30         No Label   192.168.3.0/24[V]  \
                                        0             Et1/1      172.16.1.10
31         No Label   192.168.4.0/24[V]  \
                                        0             Et1/3      172.16.1.14
PE4#
```

```
PE5#show mpls forwarding-table
Local      Outgoing   Prefix           Bytes Label   Outgoing   Next Hop
Label      Label      or Tunnel Id     Switched      interface
16         16         1.1.1.1/32       0             Et1/6      10.10.11.1
           16         1.1.1.1/32       0             Et1/5      10.10.11.5
17         17         2.2.2.2/32       0             Et1/6      10.10.11.1
           17         2.2.2.2/32       0             Et1/5      10.10.11.5
18         18         3.3.3.3/32       0             Et1/6      10.10.11.1
           18         3.3.3.3/32       0             Et1/5      10.10.11.5
19         19         4.4.4.4/32       0             Et1/6      10.10.11.1
           19         4.4.4.4/32       0             Et1/5      10.10.11.5
20         Pop Label  6.6.6.6/32       0             Et1/5      10.10.11.5
21         Pop Label  7.7.7.7/32       0             Et1/6      10.10.11.1
22         Pop Label  10.10.10.0/30     0             Et1/5      10.10.11.5
23         Pop Label  10.10.10.4/30     0             Et1/6      10.10.11.1
24         Pop Label  10.10.10.8/30     0             Et1/6      10.10.11.1
25         Pop Label  10.10.10.12/30    0             Et1/5      10.10.11.5
26         Pop Label  10.10.10.16/30    0             Et1/5      10.10.11.5
27         Pop Label  10.10.10.20/30    0             Et1/5      10.10.11.5
28         Pop Label  10.10.10.24/30    0             Et1/6      10.10.11.1
29         Pop Label  10.10.10.28/30    0             Et1/6      10.10.11.1
30         No Label   192.168.5.0/24[V]  \
                                        0             Et1/0      172.16.1.18
31         No Label   192.168.6.0/24[V]  \
                                        0             Et1/1      172.16.1.22
PE5#
```

A ce stade, le ping ne passe pas entre le SIEGE et les branches, il faudra mettre en place le MP-BGP entre les différents PE où nous avons configurer les VRF.

Entre : PE1et PE4, PE1et PE5, PE2 et PE4, PE2 et PE5 et s'assurer que les routes sont bien propagées. (Ici un exemple sur PE1, PE5 et PE2)

```
PE1#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
PE1(config)#router bgp 64501
PE1(config-router)#neighbor 5.5.5.5 remote-as 64501
PE1(config-router)#neighbor 5.5.5.5 update-source loopback 10
PE1(config-router)#
PE1(config-router)#
PE1(config-router)#address-family vpnv4
PE1(config-router-af)#neighbor 5.5.5.5 activate
PE1(config-router-af)#neighbor 5.5.5.5 send-community extended
PE1(config-router-af)#
*Oct 12 10:59:55.823: %BGP-5-ADJCHANGE: neighbor 5.5.5.5 Up
*Oct 12 10:59:56.395: %BGP-5-NBR_RESET: Neighbor 5.5.5.5 reset (Capability changed)
*Oct 12 10:59:56.403: %BGP-5-ADJCHANGE: neighbor 5.5.5.5 Down Capability changed
*Oct 12 10:59:56.407: %BGP_SESSION-5-ADJCHANGE: neighbor 5.5.5.5 IPv4 Unicast topology ba
PE1(config-router-af)#
*Oct 12 10:59:56.879: %BGP-5-ADJCHANGE: neighbor 5.5.5.5 Up
PE1(config-router-af)#
```

```
PE5#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
PE5(config)#router bgp 64501
PE5(config-router)#neighbor 1.1.1.1 remote-as 64501
PE5(config-router)#neighbor 1.1.1.1 update-source loopback 10
PE5(config-router)#
PE5(config-router)#
PE5(config-router)#
PE5(config-router)#address-family vpnv4
PE5(config-router-af)#neighbor 1.1.1.1 activate
PE5(config-router-af)#neighbor 4.4.4.4 send-community extended
% Specify remote-as or peer-group commands first
PE5(config-router-af)#address-family vpnv4
PE5(config-router-af)#neighbor 1.1.1.1 activate
PE5(config-router-af)#neighbor 1.1.1.1 send-community extended
PE5(config-router-af)#
*Oct 12 11:13:13.359: %BGP_SESSION-5-ADJCHANGE: neighbor 1.1.1.1 VPNv4 Unica
*Oct 12 11:13:13.363: %BGP-5-ADJCHANGE: neighbor 1.1.1.1 Up
*Oct 12 11:13:14.055: %BGP-5-NBR_RESET: Neighbor 1.1.1.1 reset (Peer closed
*Oct 12 11:13:14.063: %BGP-5-ADJCHANGE: neighbor 1.1.1.1 Down Peer closed th
*Oct 12 11:13:14.063: %BGP_SESSION-5-ADJCHANGE: neighbor 1.1.1.1 IPv4 Unicas
PE5(config-router-af)#
*Oct 12 11:13:14.527: %BGP-5-ADJCHANGE: neighbor 1.1.1.1 Up
PE5(config-router-af)#
```

```
PE5#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
PE5(config)#router bgp 64501
PE5(config-router)#neighbor 2.2.2.2 remote-as 64501
PE5(config-router)#neighbor 2.2.2.2 update-source loopback 10
PE5(config-router)#
PE5(config-router)#address-family vpnv4
PE5(config-router-af)#neighbor 2.2.2.2 activate
PE5(config-router-af)#neighbor 2.2.2.2 send-community extended
PE5(config-router-af)#
*Oct 12 11:20:48.011: %BGP-5-ADJCHANGE: neighbor 2.2.2.2 Up
PE5(config-router-af)#
```

Vérifications sur PE1, PE2, PE4 et PE5 :

show ip route vrf SONATEL, show ip route vrf ITSCHOOL

```
PE1#show ip route vrf SONATEL

Routing Table: SONATEL
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

      172.16.0.0/16 is variably subnetted, 2 subnets, 2 masks
C        172.16.1.0/30 is directly connected, Ethernet1/0
L        172.16.1.1/32 is directly connected, Ethernet1/0
B     192.168.1.0/24 [20/0] via 172.16.1.2, 01:07:20
B     192.168.3.0/24 [200/0] via 4.4.4.4, 00:37:15
B     192.168.5.0/24 [200/0] via 5.5.5.5, 00:17:22
PE1#
```

```
PE2#show ip route vrf ITSCHOOL

Routing Table: ITSCHOOL
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

      172.16.0.0/16 is variably subnetted, 2 subnets, 2 masks
C        172.16.1.4/30 is directly connected, Ethernet1/0
L        172.16.1.5/32 is directly connected, Ethernet1/0
B     192.168.2.0/24 [20/0] via 172.16.1.6, 00:53:35
B     192.168.4.0/24 [200/0] via 4.4.4.4, 00:24:58
B     192.168.6.0/24 [200/0] via 5.5.5.5, 00:10:36
PE2#
```

```
PE4#show ip route vrf SONATEL

Routing Table: SONATEL
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

      172.16.0.0/16 is variably subnetted, 2 subnets, 2 masks
C        172.16.1.8/30 is directly connected, Ethernet1/1
L        172.16.1.9/32 is directly connected, Ethernet1/1
B     192.168.1.0/24 [200/0] via 1.1.1.1, 00:39:20
B     192.168.3.0/24 [20/0] via 172.16.1.10, 01:03:37
PE4#show ip route vrf ITSCHOOL

Routing Table: ITSCHOOL
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

      172.16.0.0/16 is variably subnetted, 2 subnets, 2 masks
C        172.16.1.12/30 is directly connected, Ethernet1/3
L        172.16.1.13/32 is directly connected, Ethernet1/3
B     192.168.2.0/24 [200/0] via 2.2.2.2, 00:26:04
B     192.168.4.0/24 [20/0] via 172.16.1.14, 01:03:41
PE4#
```

```
PE5#show ip route vrf SONATEL

Routing Table: SONATEL
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

      172.16.0.0/16 is variably subnetted, 2 subnets, 2 masks
C        172.16.1.16/30 is directly connected, Ethernet1/0
L        172.16.1.17/32 is directly connected, Ethernet1/0
B     192.168.1.0/24 [200/0] via 1.1.1.1, 00:19:18
B     192.168.5.0/24 [20/0] via 172.16.1.18, 01:01:05
PE5#show ip route vrf ITSCHOOL

Routing Table: ITSCHOOL
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

      172.16.0.0/16 is variably subnetted, 2 subnets, 2 masks
C        172.16.1.20/30 is directly connected, Ethernet1/1
L        172.16.1.21/32 is directly connected, Ethernet1/1
B     192.168.2.0/24 [200/0] via 2.2.2.2, 00:11:47
B     192.168.6.0/24 [20/0] via 172.16.1.22, 01:01:08
PE5#
```

Vérifions aussi sur les différents CE

```
CE1#show ip bgp
BGP table version is 4, local router ID is 192.168.1.1
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
 *>  192.168.1.0     0.0.0.0                  0         32768 i
 *>  192.168.3.0     172.16.1.1                             0 64501 64402 i
 *>  192.168.5.0     172.16.1.1                             0 64501 64403 i
CE1#
```

```
CE4#sh ip bgp
BGP table version is 3, local router ID is 192.168.4.1
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
 *>  192.168.2.0     172.16.1.13                            0 64501 64405 i
 *>  192.168.4.0     0.0.0.0                  0         32768 i
CE4#
```

```
CE6#show ip bgp
BGP table version is 3, local router ID is 192.168.6.1
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
 *>  192.168.2.0     172.16.1.21                            0 64501 64405 i
 *>  192.168.6.0     0.0.0.0                  0         32768 i
CE6#
```

```
CE2#show ip bgp
BGP table version is 4, local router ID is 192.168.2.1
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
 *>  192.168.2.0     0.0.0.0                  0         32768 i
 *>  192.168.4.0     172.16.1.5                             0 64501 64406 i
 *>  192.168.6.0     172.16.1.5                             0 64501 64407 i
CE2#
```

A présent, toutes les configurations pour assurer la connective entre les entités sont faites.

Nous allons ping d'un hôte qui se situe sur le SONATEL-SIEGE vers un hôte du SONATEL-BRANCHE1 et SONATEL-BRANCHE2.

Test de connectivite pour SONATEL

Ping entre SONATEL-SIEGE vers SONATEL-BRANCHE1 et après vers SONATEL-BRANCHE2

```
PC1> show ip

NAME        : PC1[1]
IP/MASK     : 192.168.1.10/25
GATEWAY     : 192.168.1.1
DNS         :
MAC         : 00:50:79:66:68:00
LPORT       : 10126
RHOST:PORT  : 127.0.0.1:10127
MTU:        : 1500

PC1> ping 192.168.3.10
84 bytes from 192.168.3.10 icmp_seq=1 ttl=59 time=123.249 ms
84 bytes from 192.168.3.10 icmp_seq=2 ttl=59 time=122.310 ms
84 bytes from 192.168.3.10 icmp_seq=3 ttl=59 time=122.718 ms
84 bytes from 192.168.3.10 icmp_seq=4 ttl=59 time=92.111 ms
84 bytes from 192.168.3.10 icmp_seq=5 ttl=59 time=124.431 ms

PC1>
```

```
PC1> ping 192.168.5.10
84 bytes from 192.168.5.10 icmp_seq=1 ttl=59 time=120.089 ms
84 bytes from 192.168.5.10 icmp_seq=2 ttl=59 time=121.950 ms
84 bytes from 192.168.5.10 icmp_seq=3 ttl=59 time=108.670 ms
84 bytes from 192.168.5.10 icmp_seq=4 ttl=59 time=94.854 ms
84 bytes from 192.168.5.10 icmp_seq=5 ttl=59 time=112.543 ms

PC1>
```

```
PC3> ping 192.168.1.10
84 bytes from 192.168.1.10 icmp_seq=1 ttl=59 time=136.390 ms
84 bytes from 192.168.1.10 icmp_seq=2 ttl=59 time=125.255 ms
84 bytes from 192.168.1.10 icmp_seq=3 ttl=59 time=124.752 ms
84 bytes from 192.168.1.10 icmp_seq=4 ttl=59 time=127.005 ms
84 bytes from 192.168.1.10 icmp_seq=5 ttl=59 time=110.040 ms

PC3>
```

Test de connectivite pour ITSCHOOL

Ping entre ITSCHOOL-SIEGE vers ITSCHOOL-BRANCHE1 et après vers ITSCHOOL -BRANCHE2

```
PC2> show ip

NAME        : PC2[1]
IP/MASK     : 192.168.2.10/24
GATEWAY     : 192.168.2.1
DNS         :
MAC         : 00:50:79:66:68:01
LPORT       : 10128
RHOST:PORT  : 127.0.0.1:10129
MTU:        : 1500

PC2> ping 192.168.4.10
84 bytes from 192.168.4.10 icmp_seq=1 ttl=59 time=142.695 ms
84 bytes from 192.168.4.10 icmp_seq=2 ttl=59 time=126.377 ms
84 bytes from 192.168.4.10 icmp_seq=3 ttl=59 time=111.185 ms
84 bytes from 192.168.4.10 icmp_seq=4 ttl=59 time=106.359 ms
84 bytes from 192.168.4.10 icmp_seq=5 ttl=59 time=173.027 ms

PC2>
```

```
PC2> ping 192.168.6.10
84 bytes from 192.168.6.10 icmp_seq=1 ttl=59 time=137.256 ms
84 bytes from 192.168.6.10 icmp_seq=2 ttl=59 time=153.696 ms
84 bytes from 192.168.6.10 icmp_seq=3 ttl=59 time=80.337 ms
84 bytes from 192.168.6.10 icmp_seq=4 ttl=59 time=110.560 ms
84 bytes from 192.168.6.10 icmp_seq=5 ttl=59 time=95.670 ms

PC2>
```

```
PC4>
PC4> ping 192.168.2.10
84 bytes from 192.168.2.10 icmp_seq=1 ttl=59 time=153.002 ms
84 bytes from 192.168.2.10 icmp_seq=2 ttl=59 time=109.082 ms
84 bytes from 192.168.2.10 icmp_seq=3 ttl=59 time=128.211 ms
84 bytes from 192.168.2.10 icmp_seq=4 ttl=59 time=68.299 ms
84 bytes from 192.168.2.10 icmp_seq=5 ttl=59 time=172.233 ms

PC4>
```

Un trace aussi pour voir les différents nœuds

```
PC1> trace 192.168.3.10
trace to 192.168.3.10, 8 hops max, press Ctrl+C to stop
 1   192.168.1.1   17.801 ms  2.118 ms  3.374 ms
 2   172.16.1.1   42.877 ms  45.848 ms  31.116 ms
 3   10.10.10.1   93.415 ms  125.658 ms  109.048 ms
 4   172.16.1.9   93.001 ms  77.585 ms  32.561 ms
 5   172.16.1.10   123.571 ms  80.393 ms  111.373 ms
 6   *192.168.3.10   124.664 ms (ICMP type:3, code:3, Destination port unreachable)

PC1>
```


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Ces entreprises ont signé un accord de partenariat et vous ont adressé une demande qui stipule qu'elles aimeraient échanger du trafic. Nous allons alors importer les routes des deux entreprises pour établir une connexion. Pour cela, nous Configuration des Route Targets :

S'assurer que chaque VRF a les Route Targets correctement configurés pour importer et exporter les routes de l'autre entreprise. Par exemple, pour que SONATEL puisse voir les routes de IT-SCHOOL, nous devrions ajouter le Route Target de IT-SCHOOL (route-target import 64501:2) dans la configuration du VRF de SONATEL.

```
PE1#configure terminal
Enter configuration commands, one per line.  End with CNT
PE1(config)#ip vrf SONATEL
PE1(config-vrf)#rd 64501:1
PE1(config-vrf)#route-target export 64501:1
PE1(config-vrf)#route-target import 64501:2
```

```
PE2#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
PE2(config)#
PE2(config)#ip vrf ITSCHOOL
PE2(config-vrf)#rd 64501:2
PE2(config-vrf)#route-target export 64501:2
PE2(config-vrf)#route-target import 64501:1
```

```
PE4(config)#do show ip vrf brief
  Name                             Default RD          Interfaces
  ITSCHOOL                         64501:2             Et1/3
  SONATEL                          64501:1             Et1/1
PE4(config)#ip vrf SONATEL
PE4(config-vrf)#rd 64501:1
PE4(config-vrf)#route-target export 64501:1
PE4(config-vrf)#route-target import 64501:2
PE4(config-vrf)#
PE4(config-vrf)#
PE4(config-vrf)#
PE4(config-vrf)#
PE4(config-vrf)#exit
PE4(config)#
PE4(config)#ip vrf ITSCHOOL
PE4(config-vrf)#rd 64501:2
PE4(config-vrf)#route-target export 64501:2
PE4(config-vrf)#route-target import 64501:1
```

```
CE2#show ip route bgp
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

B     192.168.1.0/24 [20/0] via 172.16.1.5, 00:02:14
B     192.168.3.0/24 [20/0] via 172.16.1.5, 00:02:14
B     192.168.4.0/24 [20/0] via 172.16.1.5, 01:05:38
B     192.168.5.0/24 [20/0] via 172.16.1.5, 00:02:14
B     192.168.6.0/24 [20/0] via 172.16.1.5, 00:54:34
CE2#
```

Vérification sur CE1 et CE2

```
CE1#show ip route bgp
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

B     192.168.2.0/24 [20/0] via 172.16.1.1, 00:00:02
B     192.168.3.0/24 [20/0] via 172.16.1.1, 01:21:01
B     192.168.4.0/24 [20/0] via 172.16.1.1, 00:00:02
B     192.168.5.0/24 [20/0] via 172.16.1.1, 01:02:43
B     192.168.6.0/24 [20/0] via 172.16.1.1, 00:00:02
CE1#
```

```
CE6#show ip route bgp
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

B     192.168.1.0/24 [20/0] via 172.16.1.21, 00:50:27
B     192.168.2.0/24 [20/0] via 172.16.1.21, 01:56:36
B     192.168.3.0/24 [20/0] via 172.16.1.21, 00:50:27
B     192.168.4.0/24 [20/0] via 172.16.1.21, 00:51:31
B     192.168.5.0/24 [20/0] via 172.16.1.21, 00:50:27
CE6#
```

```
CE4#show ip route bgp
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

B     192.168.1.0/24 [20/0] via 172.16.1.13, 00:02:09
B     192.168.2.0/24 [20/0] via 172.16.1.13, 02:06:46
B     192.168.3.0/24 [20/0] via 172.16.1.13, 00:02:09
B     192.168.5.0/24 [20/0] via 172.16.1.13, 00:02:09
B     192.168.6.0/24 [20/0] via 172.16.1.13, 00:50:51
CE4#
```

C'est bon, les routes sont aussi échanger entre SONATEL et IT-SCHOOL

Test de connectivite entre SONATEL et IT-CHOOL

```
PC1> ping 192.168.2.10
84 bytes from 192.168.2.10 icmp_seq=1 ttl=59 time=106.899 ms
84 bytes from 192.168.2.10 icmp_seq=2 ttl=59 time=122.201 ms
84 bytes from 192.168.2.10 icmp_seq=3 ttl=59 time=106.651 ms
84 bytes from 192.168.2.10 icmp_seq=4 ttl=59 time=78.007 ms
84 bytes from 192.168.2.10 icmp_seq=5 ttl=59 time=64.274 ms

PC1>
```

```
PC1> ping 192.168.6.10
84 bytes from 192.168.6.10 icmp_seq=1 ttl=59 time=154.234 ms
84 bytes from 192.168.6.10 icmp_seq=2 ttl=59 time=140.767 ms
84 bytes from 192.168.6.10 icmp_seq=3 ttl=59 time=137.926 ms
84 bytes from 192.168.6.10 icmp_seq=4 ttl=59 time=137.344 ms
84 bytes from 192.168.6.10 icmp_seq=5 ttl=59 time=167.999 ms
```

```
PC2> ping 192.168.1.10
84 bytes from 192.168.1.10 icmp_seq=1 ttl=59 time=107.682 ms
84 bytes from 192.168.1.10 icmp_seq=2 ttl=59 time=155.104 ms
84 bytes from 192.168.1.10 icmp_seq=3 ttl=59 time=94.381 ms
84 bytes from 192.168.1.10 icmp_seq=4 ttl=59 time=152.153 ms
84 bytes from 192.168.1.10 icmp_seq=5 ttl=59 time=113.966 ms

PC2>
```

```
PC2> ping 192.168.3.10
84 bytes from 192.168.3.10 icmp_seq=1 ttl=59 time=131.581 ms
84 bytes from 192.168.3.10 icmp_seq=2 ttl=59 time=139.092 ms
84 bytes from 192.168.3.10 icmp_seq=3 ttl=59 time=78.472 ms
84 bytes from 192.168.3.10 icmp_seq=4 ttl=59 time=181.821 ms
84 bytes from 192.168.3.10 icmp_seq=5 ttl=59 time=209.047 ms

PC2>
```

Conclusion

Dans ce projet, nous avons mis en place une architecture IP/MPLS robuste et scalable, assurant une interconnexion fluide entre les sites des entreprises SONATEL et IT-SCHOOL via leurs VRF respectifs. Grâce à la configuration des Route Reflectors, des Route Targets, et au routage BGP VPNv4, le trafic est efficacement échangé entre les branches et sièges des deux entreprises, garantissant une communication fiable et sécurisée au sein de ce partenariat. Cette infrastructure répond aux besoins de continuité et de partage de ressources entre les entités partenaires.

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