

## Basic MPLS Tunnels

« LDP TTL Propagation (</workbook/view/service-provider-v4/task/ldp-ttl-propagation-Mjg1Mw%3D%3D>) | MPLS L3 VPN with Static Routing (</workbook/view/service-provider-v4/task/mpls-l3-vpn-with-static-routing-Mjg1NQ%3D%3D>) »

Last updated: April 23, 2016

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### Note:

**Initial Configuration & Diagrams:** Load the initial configuration files for the section named **OSPFv2**, which can be found in [CCIE SPv4 Topology Diagrams & Initial Configurations](http://labs.ine.com/workbook/view/service-provider-v4/task/ccie-spv4-topology-diagrams-initial-configs) (<http://labs.ine.com/workbook/view/service-provider-v4/task/ccie-spv4-topology-diagrams-initial-configs>). Refer to the **Base IPv4 Diagram** in order to complete this task.

## Task

- Disable OSPF on R1 and XR2.
- Configure LDP on all of the transit links between R2, R3, R4, R5, R6, and XR1.
- Configure BGP on R1, R2, XR1, and XR2 as follows:
  - R1 should be in AS 1.
  - R2 and XR1 should be in AS 100.
  - XR2 should be in AS 20.
  - R1 and R2 should peer EBGP using their connected link.
  - R2 and XR1 should peer iBGP using the Loopback0 interfaces, and use **next-hop-self**.
  - XR1 and XR2 should peer EBGP using their connected link.
  - Advertise the prefix 1.1.1.1/32 into BGP on R1.
  - Advertise the prefix 20.20.20.20/32 into BGP on XR2.
- Once complete R1 and XR2 should be able to reach each other's Loopback0 interfaces when sourcing traffic from their own Loopback0 interface.

## Configuration Click to collapse

```
R1:
no router ospf 1
!
router bgp 1
network 1.1.1.1 mask 255.255.255.255
neighbor 10.1.2.2 remote-as 100
```

```
R2:
mpls label protocol ldp
!
interface GigabitEthernet1.23
mpls ip
!
interface GigabitEthernet1.24
mpls ip
!
router bgp 100
neighbor 10.1.2.1 remote-as 1
neighbor 19.19.19.19 remote-as 100
neighbor 19.19.19.19 update-source Loopback0
neighbor 19.19.19.19 next-hop-self
```

```
R3:
mpls label protocol ldp
!
interface GigabitEthernet1.23
mpls ip
!
interface GigabitEthernet1.34
mpls ip
!
interface GigabitEthernet1.36
mpls ip
!
mpls ldp router-id Loopback0
```

```
R4:
mpls label protocol ldp
!
interface GigabitEthernet1.24
mpls ip
!
interface GigabitEthernet1.34
mpls ip
!
interface GigabitEthernet1.45
mpls ip
!
interface GigabitEthernet1.46
mpls ip
!
mpls ldp router-id Loopback0
```

```
R5:
mpls label protocol ldp
!
interface GigabitEthernet1.45
  mpls ip
!
```

```
interface GigabitEthernet1.56
  mpls ip
!
interface GigabitEthernet1.519
  mpls ip
!
mpls ldp router-id Loopback0
```

```
R6:
mpls label protocol ldp
!
interface GigabitEthernet1.36
  mpls ip
!
interface GigabitEthernet1.46
  mpls ip
!
interface GigabitEthernet1.56
  mpls ip
!
interface GigabitEthernet1.619
  mpls ip
!
mpls ldp router-id Loopback0
```

```
XR1:
route-policy PASS
  pass
end-policy
!
router bgp 100
  address-family ipv4 unicast
  !
  neighbor 2.2.2.2
    remote-as 100
    update-source Loopback0
    address-family ipv4 unicast
      next-hop-self
  !
  !
  neighbor 10.19.20.20
    remote-as 20
    address-family ipv4 unicast
    route-policy PASS in
    route-policy PASS out
  !
  !
  !
```

```
mpls ldp
router-id 19.19.19.19
interface GigabitEthernet0/0/0/0.519
!
interface GigabitEthernet0/0/0/0.619
!
XR2:
no router ospf 1
!
route-policy PASS
pass
end-policy
!
router bgp 20
address-family ipv4 unicast
network 20.20.20.20/32
!
neighbor 10.19.20.19
remote-as 100
address-family ipv4 unicast
route-policy PASS in
route-policy PASS out
!
!
!
end
```

## Verification

All devices in the core of the network have IGP routes and MPLS labels to each other. The only important labels in this example is the Loopback interfaces of R2 and XR1.

R2#show mpls forwarding-table

Local Label	Outgoing Label	Prefix or Tunnel Id	Bytes Switched	Outgoing interface	Next Hop
16	23	19.19.19.19/32	0	Gi1.23	20.2.3.3
	23	19.19.19.19/32	0	Gi1.24	20.2.4.4
18	22	10.19.20.0/24	0	Gi1.23	20.2.3.3
	22	10.19.20.0/24	0	Gi1.24	20.2.4.4
19	29	20.6.19.0/24	0	Gi1.23	20.2.3.3
	28	20.6.19.0/24	0	Gi1.24	20.2.4.4
32	20	6.6.6.6/32	0	Gi1.23	20.2.3.3
	20	6.6.6.6/32	0	Gi1.24	20.2.4.4
33	19	5.5.5.5/32	0	Gi1.24	20.2.4.4
34	Pop Label	4.4.4.4/32	0	Gi1.24	20.2.4.4
35	Pop Label	3.3.3.3/32	0	Gi1.23	20.2.3.3
36	27	20.5.6.0/24	0	Gi1.23	20.2.3.3
	26	20.5.6.0/24	0	Gi1.24	20.2.4.4
37	Pop Label	20.4.6.0/24	0	Gi1.24	20.2.4.4
38	27	20.5.19.0/24	0	Gi1.24	20.2.4.4
39	Pop Label	20.3.4.0/24	0	Gi1.23	20.2.3.3
	Pop Label	20.3.4.0/24	0	Gi1.24	20.2.4.4
40	Pop Label	20.3.6.0/24	0	Gi1.23	20.2.3.3
41	Pop Label	20.4.5.0/24	0	Gi1.24	20.2.4.4

R2#show ip cef 19.19.19.19 detail

19.19.19.19/32, epoch 2, per-destination sharing

local label info: global/16

1 RR source [no flags]

nexthop 20.2.3.3 GigabitEthernet1.23 label 23

nexthop 20.2.4.4 GigabitEthernet1.24 label 23

RP/0/0/CPU0:XR1#show mpls forwarding

Sun May 3 14:27:48.208 UTC

Local Label	Outgoing Label	Prefix or ID	Outgoing Interface	Next Hop	Bytes Switched
16002	18	3.3.3.3/32	Gi0/0/0/0.619	20.6.19.6	0
16003	19	4.4.4.4/32	Gi0/0/0/0.519	20.5.19.5	0
	19	4.4.4.4/32	Gi0/0/0/0.619	20.6.19.6	0
16004	Pop	5.5.5.5/32	Gi0/0/0/0.519	20.5.19.5	2256
16005	17	2.2.2.2/32	Gi0/0/0/0.519	20.5.19.5	2357
	17	2.2.2.2/32	Gi0/0/0/0.619	20.6.19.6	0
16006	Pop	6.6.6.6/32	Gi0/0/0/0.619	20.6.19.6	211072
16008	Pop	20.3.6.0/24	Gi0/0/0/0.619	20.6.19.6	0
16009	24	20.2.3.0/24	Gi0/0/0/0.619	20.6.19.6	816
16010	Pop	20.5.6.0/24	Gi0/0/0/0.519	20.5.19.5	0
	Pop	20.5.6.0/24	Gi0/0/0/0.619	20.6.19.6	0
16011	Pop	20.4.5.0/24	Gi0/0/0/0.519	20.5.19.5	0
16012	Pop	20.4.6.0/24	Gi0/0/0/0.619	20.6.19.6	0
16013	26	20.3.4.0/24	Gi0/0/0/0.519	20.5.19.5	0
	26	20.3.4.0/24	Gi0/0/0/0.619	20.6.19.6	0
16014	25	20.2.4.0/24	Gi0/0/0/0.519	20.5.19.5	0
	25	20.2.4.0/24	Gi0/0/0/0.619	20.6.19.6	0
16015	21	10.1.2.0/24	Gi0/0/0/0.519	20.5.19.5	0

R2 and XR1 peer iBGP with each other, along with EBGP to R1 and XR2 respectively.

```
R2#show bgp ipv4 unicast summary
```

```
BGP router identifier 2.2.2.2, local AS number 100
```

```
BGP table version is 4, main routing table version 4
```

```
2 network entries using 496 bytes of memory
```

```
2 path entries using 240 bytes of memory
```

```
2/2 BGP path/bestpath attribute entries using 496 bytes of memory
```

```
2 BGP AS-PATH entries using 48 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
```

```
BGP using 1280 total bytes of memory
```

```
BGP activity 2/0 prefixes, 2/0 paths, scan interval 60 secs
```

Neighbor	V	AS	MsgRcvd	MsgSent	TblVer	InQ	OutQ	Up/Down	State/PfxRcd
10.1.2.1	4	1	18	17	4	0	0	00:12:32	1
19.19.19.19	4	100	13	15	4	0	0	00:10:03	1

```
RP/0/0/CPU0:XR1#show bgp ipv4 unicast summary
```

```
Sun May 3 14:20:49.277 UTC
```

```
BGP router identifier 19.19.19.19, local AS number 100
```

```
BGP generic scan interval 60 secs
```

```
BGP table state: Active
```

```
Table ID: 0xe0000000 RD version: 4
```

```
BGP main routing table version 4
```

```
BGP scan interval 60 secs
```

```
BGP is operating in STANDALONE mode.
```

Process	RcvTblVer	bRIB/RIB	LabelVer	ImportVer	SendTblVer	StandbyVer
Speaker	4	4	4	4	4	4

Neighbor	Spk	AS	MsgRcvd	MsgSent	TblVer	InQ	OutQ	Up/Down	St/PfxRcd
2.2.2.2	0	100	16	13	4	0	0	00:10:26	1
10.19.20.20	0	20	9	9	4	0	0	00:05:49	1

R1 and XR2 advertise their Loopback0 networks into BGP, which are then exchanged through the MPLS core via R2 and XR1.

```
R1#show bgp ipv4 unicast
BGP table version is 4, local router ID is 1.1.1.1
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
*> 1.1.1.1/32	0.0.0.0	0		32768	i
*> 20.20.20.20/32	10.1.2.2			0 100	20 i

```
RP/0/0/CPU0:XR2#show bgp ipv4 unicast
Sun May 3 14:21:35.944 UTC
BGP router identifier 20.20.20.20, local AS number 20
BGP generic scan interval 60 secs
BGP table state: Active
Table ID: 0xe0000000 RD version: 4
BGP main routing table version 4
BGP scan interval 60 secs
```

```
Status codes: s suppressed, d damped, h history, * valid, > best
               i - internal, r RIB-failure, S stale, N Nexthop-discard
```

```
Origin codes: i - IGP, e - EGP, ? - incomplete
```

Network	Next Hop	Metric	LocPrf	Weight	Path
*> 1.1.1.1/32	10.19.20.19			0 100	1 i
*> 20.20.20.20/32	0.0.0.0	0		32768	i

```
Processed 2 prefixes, 2 paths
```

Note that R1 and XR2 do not run MPLS.

```
R1#show mpls forwarding-table
no MPLS apps enabled or MPLS not enabled on any interfaces
```

```
R1#show ip cef 20.20.20.20
20.20.20.20/32
  nexthop 10.1.2.2 GigabitEthernet1.12
```

```
RP/0/3/CPU0:XR2#show mpls forwarding
Sun May 3 14:22:23.560 UTC
```

```
RP/0/0/CPU0:XR2#show cef ipv4 1.1.1.1/32
Sun May 3 14:22:35.960 UTC
1.1.1.1/32, version 1399, internal 0x14000001 0x0 (ptr 0xa0edc674) [1], 0x0 (0x0), 0x0 (0x0)
Updated May 3 14:15:05.181
local adjacency 10.19.20.19
Prefix Len 32, traffic index 0, precedence n/a, priority 4
via 10.19.20.19, 2 dependencies, recursive, bgp-ext [flags 0x6020]
path-idx 0 NHID 0x0 [0xa0edb874 0x0]
next hop 10.19.20.19 via 10.19.20.19/32
```

When R2 and XR1 exchange the BGP routes from R1 and XR2, the next-hop value is set to their local Loopback0 interfaces.

```
R2#show bgp ipv4 unicast 20.20.20.20/32
BGP routing table entry for 20.20.20.20/32, version 4
Paths: (1 available, best #1, table default)

  Advertised to update-groups:
    1
  Refresh Epoch 1
  20
  19.19.19.19 (metric 4) from 19.19.19.19 (19.19.19.19)
    Origin IGP, metric 0, localpref 100, valid, internal, best
    rx pathid: 0, tx pathid: 0x0
```

```
RP/0/0/CPU0:XR1#show bgp ipv4 unicast 1.1.1.1/32
Sun May  3 14:39:37.349 UTC
BGP routing table entry for 1.1.1.1/32
Versions:
  Process          bRIB/RIB  SendTblVer
  Speaker          3         3
Last Modified: May  3 14:12:22.451 for 00:27:15
Paths: (1 available, best #1)

  Advertised to peers (in unique update groups):
    10.19.20.20
  Path #1: Received by speaker 0
  Advertised to peers (in unique update groups):
    10.19.20.20
  1
  2.2.2.2 (metric 4) from 2.2.2.2 (2.2.2.2)
    Origin IGP, metric 0, localpref 100, valid, internal, best, group-best, import-candidate
    Received Path ID 0, Local Path ID 1, version 3
```

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Since R2 has an MPLS label for 19.19.19.19, and likewise XR1 has an MPLS label for 2.2.2.2, traffic is MPLS encapsulated when going to 1.1.1.1 and 20.20.20.20 using label values seen below.

```
R2#show ip cef 20.20.20.20 detail
20.20.20.20/32, epoch 2, flags [rib only nolabel, rib defined all labels]
  recursive via 19.19.19.19
    nexthop 20.2.3.3 GigabitEthernet1.23 label 23
    nexthop 20.2.4.4 GigabitEthernet1.24 label 23
```

```
R2#show ip cef 19.19.19.19 detail
19.19.19.19/32, epoch 2, per-destination sharing
  local label info: global/16
  1 RR source [no flags]
  nexthop 20.2.3.3 GigabitEthernet1.23 label 23
  nexthop 20.2.4.4 GigabitEthernet1.24 label 23
```

```
R2#show mpls forwarding-table 19.19.19.19
Local   Outgoing Prefix          Bytes Label  Outgoing  Next Hop
Label   Label    or Tunnel Id    Switched     interface
16      23       19.19.19.19/32  0            Gi1.23    20.2.3.3
        23       19.19.19.19/32  0            Gi1.24    20.2.4.4
```

```
RP/0/0/CPU0:XR1#show cef ipv4 1.1.1.1/32 detail
Sun May  3 14:40:10.927 UTC
1.1.1.1/32, version 3133, internal 0x14000001 0x0 (ptr 0xa0edbe74) [1], 0x0 (0x0), 0x0 (0x0)
Updated May  3 14:26:35.123
  local adjacency 20.5.19.5
  Prefix Len 32, traffic index 0, precedence n/a, priority 4
  gateway array (0xa0d30310) reference count 1, flags 0x4030, source rib (6), 0 backups
    [1 type 3 flags 0x680a1 (0xa0df1a28) ext 0x218 (0xa16600a8)]
  LW-LDI[type=0, refc=0, ptr=0x0, sh-ldi=0x0]
  via 2.2.2.2, 2 dependencies, recursive [flags 0x6000]
  path-idx 0 NHID 0x0 [0xa0edbaf4 0x0]
  next hop 2.2.2.2 via 2.2.2.2/32

  Load distribution: 0 1 (refcount 1)

  Hash OK Interface          Address
  0   Y GigabitEthernet0/0/0.519 20.5.19.5
  1   Y GigabitEthernet0/0/0.619 20.6.19.6
```

```
RP/0/0/CPU0:XR1#show ip cef 2.2.2.2/32 detail
Sun May  3 14:43:13.674 UTC
2.2.2.2/32, version 601, internal 0x4004001 0x0 (ptr 0xa0edbaf4) [2], 0x0 (0xa0ea7878), 0x228 (0xa16601b0)
Updated May  3 14:10:18.089
  local adjacency 20.5.19.5
  Prefix Len 32, traffic index 0, precedence n/a, priority 3
  gateway array (0xa0d309a0) reference count 15, flags 0x68, source lsd (4), 1 backups
    [6 type 5 flags 0x8081 (0xa14106e0) ext 0x0 (0x0)]
  LW-LDI[type=5, refc=3, ptr=0xa0ea7878, sh-ldi=0xa14106e0]
  via 20.5.19.5, GigabitEthernet0/0/0.519, 8 dependencies, weight 0, class 0 [flags 0x0]
  path-idx 0 NHID 0x0 [0xa16c80cc 0x0]
  next hop 20.5.19.5
  tx adjacency
```

```

local label 16005      labels imposed {17}
via 20.6.19.6, GigabitEthernet0/0/0/0.619, 10 dependencies, weight 0, class 0 [flags 0x0]
path-idx 1 NHID 0x0 [0xa16c8228 0x0]
next hop 20.6.19.6
tx adjacency
local label 16005      labels imposed {17}

```

Load distribution: 0 1 (refcount 6)

Hash	OK	Interface	Address
0	Y	GigabitEthernet0/0/0/0.519	20.5.19.5
1	Y	GigabitEthernet0/0/0/0.619	20.6.19.6

RP/0/0/CPU0:XR1#show mpls forwarding prefix 2.2.2.2/32

Sun May 3 14:40:59.984 UTC

Local Label	Outgoing Label	Prefix or ID	Outgoing Interface	Next Hop	Bytes Switched
16005	17	2.2.2.2/32	Gi0/0/0/0.519	20.5.19.5	3792
	17	2.2.2.2/32	Gi0/0/0/0.619	20.6.19.6	0

Multiple outgoing labels are shown because R2 and XR1 have multiple equal cost paths to reach each other's Loopback0 interfaces. The final result of this configuration is that R1 and XR2 have IP reachability to each other, even though the devices in the core (R3, R4, R5, & R6) do not have IP routing information about 1.1.1.1/32 or 20.20.20.20/32.

```
R1#ping 20.20.20.20 source 1.1.1.1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 20.20.20.20, timeout is 2 seconds:
Packet sent with a source address of 1.1.1.1
!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 4/7/13 ms
```

```
RP/0/0/CPU0:XR2#ping 1.1.1.1 source 20.20.20.20
Sun May 3 14:45:29.435 UTC
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 = 1/9/29 ms
```

```
R3#show ip route 1.1.1.1
% Network not in table
```

```
R3#show ip route 20.20.20.20
% Network not in table
```

```
R4#show ip route 1.1.1.1
% Network not in table
```

```
R4#show ip route 20.20.20.20
% Network not in table
```

```
R5#show ip route 1.1.1.1
% Network not in table
```

```
R5#show ip route 20.20.20.20
% Network not in table
```

```
R6#show ip route 1.1.1.1
% Network not in table
```

```
R6#show ip route 20.20.20.20
% Network not in table
```

MPLS forwarding table counters show that traffic between the Loopback0 networks of R1 and XR2 is using a Labeled Switch Path (LSP) between R2 and XR1's Loopback0 networks.

```
RP/0/0/CPU0:XR2#ping 1.1.1.1 source 20.20.20.20 count 100
Sun May 3 15:03:20.092 UTC
Type escape sequence to abort.
Sending 100, 100-byte ICMP Echos to 1.1.1.1, timeout is 2 seconds:
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
Success rate is 100 percent (100/100), round-trip min/avg/max = 1/17/29 ms
```

```
R4#show mpls forwarding-table
```

Local Label	Outgoing Label	Prefix or Tunnel Id	Bytes Switched	Outgoing interface	Next Hop
17	Pop Label	2.2.2.2/32	27709	Gi1.24	20.2.4.2
18	Pop Label	3.3.3.3/32	0	Gi1.34	20.3.4.3
19	Pop Label	5.5.5.5/32	0	Gi1.45	20.4.5.5
20	Pop Label	6.6.6.6/32	0	Gi1.46	20.4.6.6
21	Pop Label	10.1.2.0/24	0	Gi1.24	20.2.4.2
22	22	10.19.20.0/24	0	Gi1.45	20.4.5.5
	22	10.19.20.0/24	0	Gi1.46	20.4.6.6
23	23	19.19.19.19/32	0	Gi1.45	20.4.5.5
	23	19.19.19.19/32	1756	Gi1.46	20.4.6.6
24	Pop Label	20.2.3.0/24	0	Gi1.24	20.2.4.2
	Pop Label	20.2.3.0/24	0	Gi1.34	20.3.4.3
25	Pop Label	20.3.6.0/24	0	Gi1.34	20.3.4.3
	Pop Label	20.3.6.0/24	0	Gi1.46	20.4.6.6
26	Pop Label	20.5.6.0/24	0	Gi1.45	20.4.5.5
	Pop Label	20.5.6.0/24	0	Gi1.46	20.4.6.6
27	Pop Label	20.5.19.0/24	0	Gi1.45	20.4.5.5
28	Pop Label	20.6.19.0/24	0	Gi1.46	20.4.6.6

« LDP TTL Propagation (/workbook/view/service-provider-v4/task/ldp-ttl-propagation-Mjg1Mw%3D%3D) | MPLS L3 VPN with Static Routing (/workbook/view/service-provider-v4/task/mpls-l3-vpn-with-static-routing-Mjg1NQ%3D%3D) »