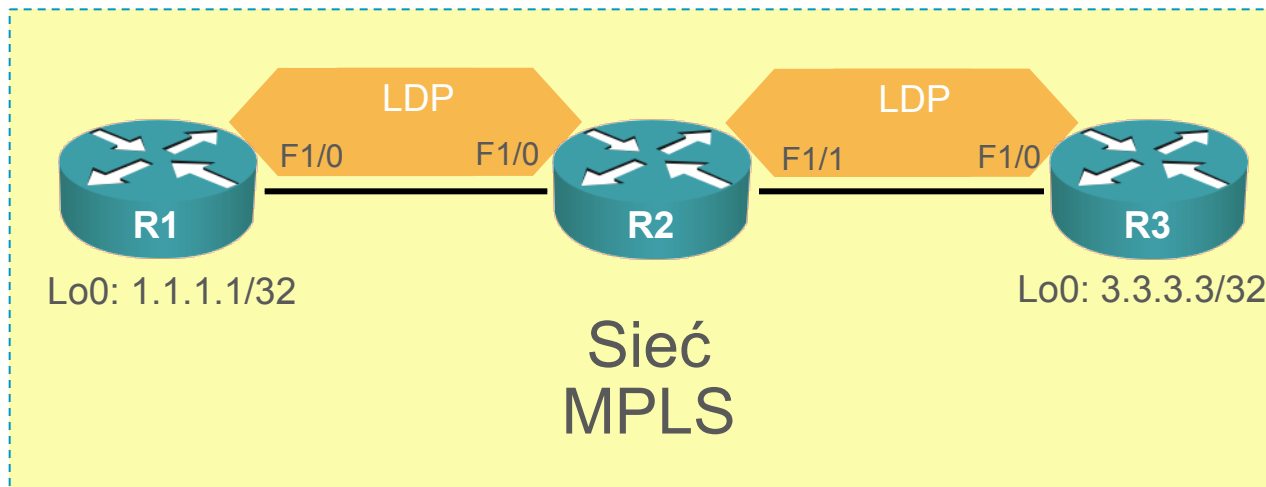


Dzisiejsze menu

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Pojedyncza etykieta MPLS

- Jeden proces IGP/LDP w całej sieci.
- Capture zawsze na R1 F1/0.



Pakiet MPLS z pojedynczą etykietą

No.	Time	Source	Destination	Protocol	Length	Info
23	11.816898	1.1.1.1	3.3.3.3	ICMP	118	Echo (ping) request
24	11.848812	3.3.3.3	1.1.1.1	ICMP	114	Echo (ping) reply
25	11.859601	1.1.1.1	3.3.3.3	ICMP	118	Echo (ping) request
26	11.892915	3.3.3.3	1.1.1.1	ICMP	114	Echo (ping) reply

```

▶ Frame 23: 118 bytes on wire (944 bits), 118 bytes captured (944 bits)
▶ Ethernet II, Src: ca:00:01:b2:00:1c (ca:00:01:b2:00:1c), Dst: ca:01:01:b2:00:1c (ca:01:01:b2:00:1c)
▼ MultiProtocol Label Switching Header, Label: 18, Exp: 0, S: 1, TTL: 255
    MPLS Label: 18
    MPLS Experimental Bits: 0
    MPLS Bottom Of Label Stack: 1
    MPLS TTL: 255
▶ Internet Protocol Version 4, Src: 1.1.1.1 (1.1.1.1), Dst: 3.3.3.3 (3.3.3.3)
▶ Internet Control Message Protocol
  
```

```

0000  ca 01 01 b2 00 1c ca 00 01 b2 00 1c 88 47 00 01  .....G..
0010  21 ff 45 00 00 64 00 00 00 00 ff 01 b3 91 01 01  !.E..d..
0020  01 01 03 03 03 03 08 00 e9 ab 00 00 00 00 00 00  .....
0030  00 00 02 4e 92 50 ab cd ab cd ab cd ab cd ab cd  ...N.P..
  
```

Rozgłoszenie etykiety LDP

No.	Time	Source	Destination	Protoc	Length	Info
128	48.134332	2.2.2.2	1.1.1.1	LDP	113	Initialization Message
129	48.177301	1.1.1.1	2.2.2.2	LDP	121	Initialization Message Keep Alive
130	48.231463	2.2.2.2	1.1.1.1	LDP	273	Address Message Label Mapping Mess
131	48.316943	1.1.1.1	2.2.2.2	LDP	342	Address Message Label Mapping Mess

```
Frame 130: 273 bytes on wire (2184 bits), 273 bytes captured (2184 bits)
Ethernet II, Src: ca:01:01:b2:00:1c (ca:01:01:b2:00:1c), Dst: ca:00:01:b2:00:1c (ca:00:01:b2:00:1c)
Internet Protocol Version 4, Src: 2.2.2.2 (2.2.2.2), Dst: 1.1.1.1 (1.1.1.1)
Transmission Control Protocol, Src Port: 59311 (59311), Dst Port: ldp (646), Seq: 60, Ack: 68, Len: 219
Label Distribution Protocol
Label Distribution Protocol
  Version: 1
  PDU Length: 197
  LSR ID: 2.2.2.2 (2.2.2.2)
  Label Space ID: 0
```

Pakiet skrócony

- ▼ FEC Elements
 - ▼ FEC Element 1
 - FEC Element Type: Prefix FEC (2)
 - FEC Element Address Type: IPv4 (1)
 - FEC Element Length: 32
 - Prefix: 3.3.3.3
- ▼ Generic Label TLV
 - 00.. = TLV Unknown bits: Known TLV, do not Forward (0x00)
 - TLV Type: Generic Label TLV (0x200)
 - TLV Length: 4
 - Generic Label: 18

Weryfikacja: Jedna etykieta MPLS

- Ping z R1 do R3

```
Rack1R1#sh ip cef 3.3.3.3  
3.3.3.3/32  
  nexthop 10.1.12.2 FastEthernet1/0 label 18
```

```
Rack1R1#show mpls forwarding-table
```

Local Label	Outgoing Label	Prefix or Tunnel Id	Bytes Switched	Label	Outgoing interface	Next Hop
16	17	5.5.5.5/32[V]	0		Fa1/1.30	10.3.14.4
17	No Label	12.1.1.0/30[V]	0		aggregate/aa	
18	No Label	12ckt(102)	408060		Fa1/1.10	point2point
19	explicit-n	2.2.2.2/32	0		Fa1/0	10.1.12.2
20	explicit-n	10.1.23.0/24	0		Fa1/0	10.1.12.2
21	18	3.3.3.3/32	0		Fa1/0	10.1.12.2
22	19	10.2.35.0/24	0		Fa1/0	10.1.12.2
26	23	31.1.1.0/30[V]	0		Fa1/0	10.1.12.2
27	24	32.1.1.0/30[V]	0		Fa1/0	10.1.12.2
29	Pop Label	4.4.4.4/32[V]	0		Fa1/1.30	10.3.14.4
30	Pop Label	10.1.45.0/24[V]	0		Fa1/1.30	10.3.14.4

QoS: Mapowanie DSCP do EXP

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000	10.1.12.2	224.0.0.2	LDP	76	Hello Message
2	1.765789	1.1.1.1	3.3.3.3	ICMP	118	Echo (ping) request id=0x0003,
3	1.798598	3.3.3.3	1.1.1.1	ICMP	114	Echo (ping) reply id=0x0003,
4	1.809515	1.1.1.1	3.3.3.3	ICMP	118	Echo (ping) request id=0x0003,

```

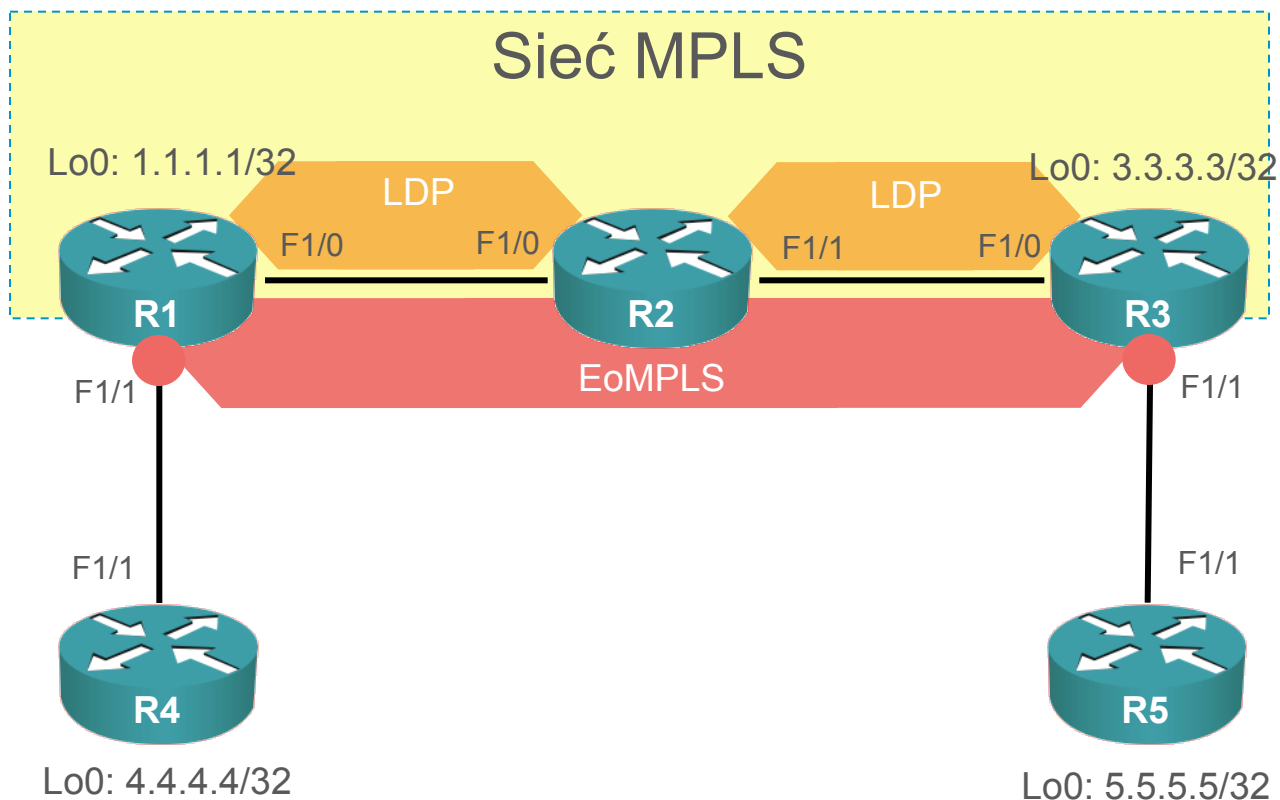
.....
▶ Frame 2: 118 bytes on wire (944 bits), 118 bytes captured (944 bits)
▶ Ethernet II, Src: ca:00:01:b2:00:1c (ca:00:01:b2:00:1c), Dst: ca:01:01:b2:00:1c (ca:01:01:b2:00:1c)
▼ MultiProtocol Label Switching Header, Label: 18, Exp: 5, S: 1, TTL: 255
    MPLS Label: 18
    MPLS Experimental Bits: 5
    MPLS Bottom Of Label Stack: 1
    MPLS TTL: 255
▼ Internet Protocol Version 4, Src: 1.1.1.1 (1.1.1.1), Dst: 3.3.3.3 (3.3.3.3)
    Version: 4
    Header length: 20 bytes
    ▶ Differentiated Services Field: 0xb8 (DSCP 0x2e: Expedited Forwarding; ECN: 0x00: Not-ECT (Not ECN-Capable Transport))
    Total Length: 100
    Identification: 0x000f (15)
    ▶ Flags: 0x00
    Fragment offset: 0
    Time to live: 255
    Protocol: ICMP (1)
  
```

```

.....
0010 2b ff 45 b8 00 64 00 0f 00 00 ff 01 b2 ca 01 01 +.E..d.. .....
0020 01 01 03 03 03 03 08 00 31 e7 00 03 00 00 00 00 ..... 1.....
0030 00 00 02 58 4a 08 ab cd ab cd ab cd ab cd ...XJ... .....
0040 ab cd ab cd ab cd ab cd ab cd ab cd ab cd .....
  
```

EoMPLS VC Type-5 + CW

- Port-based xconnect z control word (CW)



EoMPLS Port-based VC-Type 5 + CW

- Dwie etykiety + Control Word

No.	Time	Source	Destination	Protocol	Length	Info
35	18.532425	1.1.1.1	3.3.3.3	LDP	80	Hello Message
36	19.652367	4.4.4.4	5.5.5.5	ICMP	140	Echo (ping) request id=0x0004, seq=0/0, ttl=255
37	19.695485	5.5.5.5	4.4.4.4	ICMP	136	Echo (ping) reply id=0x0004, seq=0/0, ttl=255
38	19.716102	4.4.4.4	5.5.5.5	ICMP	140	Echo (ping) request id=0x0004, seq=1/256, ttl=255

Frame 36: 140 bytes on wire (1120 bits), 140 bytes captured (1120 bits)

Ethernet II, Src: ca:09:02:89:00:1c (ca:09:02:89:00:1c), Dst: ca:0b:02:89:00:1c (ca:0b:02:89:00:1c)

MultiProtocol Label Switching Header, Label: 18, Exp: 0, S: 0, TTL: 255

MultiProtocol Label Switching Header, Label: 21, Exp: 0, S: 1, TTL: 255

- MPLS Label: 21
- MPLS Experimental Bits: 0
- MPLS Bottom Of Label Stack: 1
- MPLS TTL: 255

PW Ethernet Control Word

- Sequence Number: 0

Ethernet II, Src: cc:0d:02:a2:00:00 (cc:0d:02:a2:00:00), Dst: cc:0e:02:a2:00:00 (cc:0e:02:a2:00:00)

Internet Protocol Version 4, Src: 4.4.4.4 (4.4.4.4), Dst: 5.5.5.5 (5.5.5.5)

Internet Control Message Protocol

0010	20 ff 00 01 51 ff 00 00 00 00 cc 0e 02 a2 00 00	. . . 0
0020	cc 0d 02 a2 00 00 08 00 45 00 00 64 00 14 00 00 E . . d
0030	ff 01 a9 73 04 04 04 04 05 05 05 05 08 00 ba dd	. . . s
0040	00 04 00 00 00 00 00 00 00 98 c2 d0 ab cd ab cd
0050	ab cd ab cd ab cd ab cd ab cd ab cd ab cd ab cd
0060	ab cd ab cd ab cd ab cd ab cd ab cd ab cd ab cd
0070	ab cd ab cd ab cd ab cd ab cd ab cd ab cd ab cd
0080	ab cd ab cd ab cd ab cd ab cd ab cd ab cd

EoMPLS Port-based VC-Type 5 + CW

```
Rack1R1#sh mpls for
Local      Outgoing   Prefix          Bytes Label    Outgoing   Next Hop
Label      Label      or Tunnel Id    Switched       interface
16         Pop Label  2.2.2.2/32      0              Fa1/0      10.1.12.2
17         Pop Label  10.1.23.0/24    0              Fa1/0      10.1.12.2
18         18         3.3.3.3/32      0              Fa1/0      10.1.12.2
21         No Label   12ckt(101)      158687         Fa1/1      point2point
```

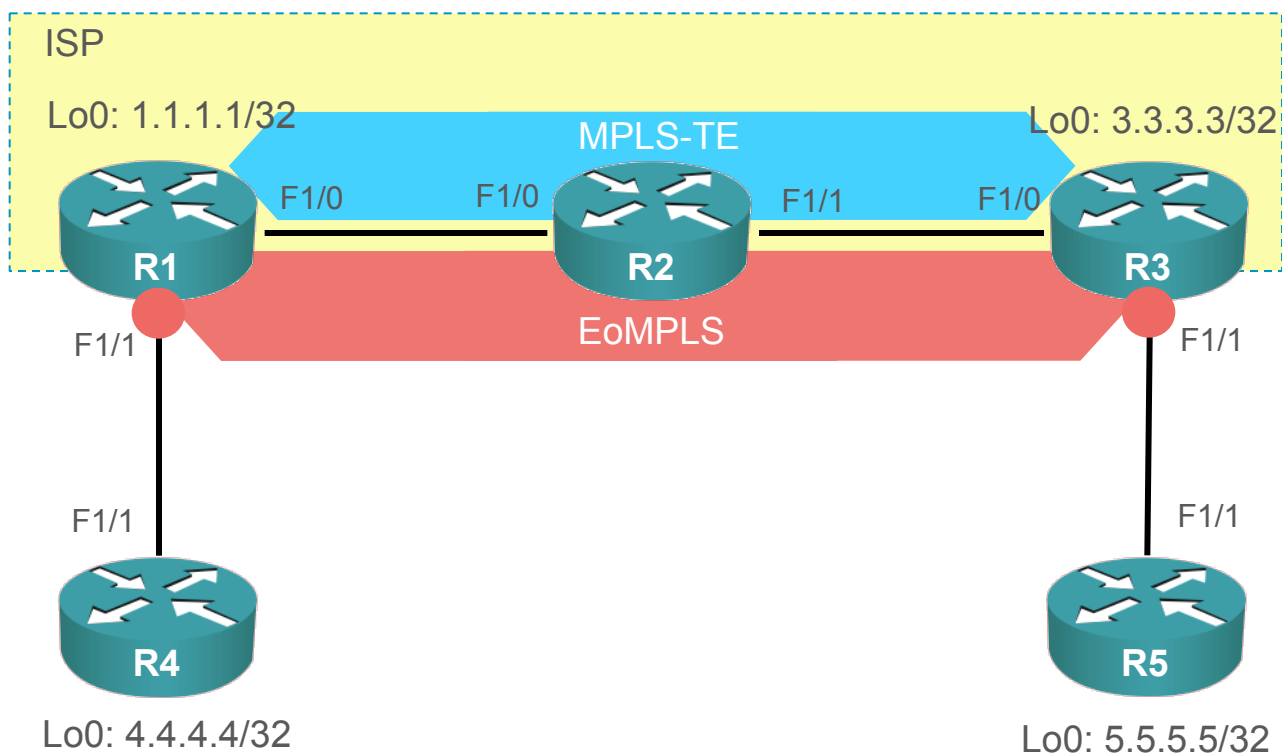
```
Rack1R1#sh mpls 12transport vc det | i label
Output interface: Fa1/0, imposed label stack {18 21}
MPLS VC labels: local 21, remote 21
```

```
Rack1R1#sh mpls 12transport binding
Destination Address: 3.3.3.3, VC ID: 101
Local Label: 21
  Cbit: 1, VC Type: Ethernet, GroupID: 0
  MTU: 1500, Interface Desc: n/a
  VCCV: CC Type: CW [1], RA [2]
  CV Type: LSPV [2]
Remote Label: 21
  Cbit: 1, VC Type: Ethernet, GroupID: 0
  MTU: 1500, Interface Desc: n/a
  VCCV: CC Type: CW [1], RA [2]
  CV Type: LSPV [2]
```

```
R1:
!
interface FastEthernet1/1
 xconnect 3.3.3.3 101 encapsulation mpls
!
```

EoMPLS VC Type-5 + CW + TE

- VLAN-based xconnect w trybie Ethernet z control word (CW)



EoMPLS VC Type-5 + CW + TE

- PW na podinterfejsie w trybie Ethernet + CW poprzez tunel TE

No.	Time	Source	Destination	Protocol	Length	Info
740	469.384033	3.3.3.3	1.1.1.1	UDP	72	keep alive message
741	469.598880	1.1.1.1	3.3.3.3	TCP	60	ldp > 12768 [ACK] Seq=314 Ack=314 Win=3815 Len=0
742	470.276787	4.4.4.4	5.5.5.5	ICMP	140	Echo (ping) request id=0x0003, seq=0/0, ttl=255
743	470.320227	5.5.5.5	4.4.4.4	ICMP	136	Echo (ping) reply id=0x0003, seq=0/0, ttl=255
744	470.342060	4.4.4.4	5.5.5.5	ICMP	140	Echo (ping) request id=0x0003, seq=1/256, ttl=255

```

> Frame 742: 140 bytes on wire (1120 bits), 140 bytes captured (1120 bits)
> Ethernet II, Src: ca:00:07:00:00:1c (ca:00:07:00:00:1c), Dst: ca:01:07:00:00:1c (ca:01:07:00:00:1c)
> MultiProtocol Label Switching Header, Label: 19, Exp: 0, S: 0, TTL: 255
> MultiProtocol Label Switching Header, Label: 20, Exp: 0, S: 1, TTL: 255
> PW Ethernet Control Word
< Ethernet II, Src: cc:03:07:01:00:00 (cc:03:07:01:00:00), Dst: cc:04:07:01:00:00 (cc:04:07:01:00:00)
  > Destination: cc:04:07:01:00:00 (cc:04:07:01:00:00)
  > Source: cc:03:07:01:00:00 (cc:03:07:01:00:00)
  Type: IP (0x0800)
> Internet Protocol Version 4, Src: 4.4.4.4 (4.4.4.4), Dst: 5.5.5.5 (5.5.5.5)
> Internet Control Message Protocol
  
```

```

0010  30 ff 00 01 41 ff 00 00 00 00 cc 04 07 01 00 00  0...A... ..
0020  cc 03 07 01 00 00 08 00 45 00 00 64 00 0f 00 00  .....E..d....
0030  ff 01 a9 78 04 04 04 04 05 05 05 05 08 00 87 a6  ...X... ..
0040  00 03 00 00 00 00 00 00 00 10 f6 90 ab cd ab cd  .....
0050  ab cd ab cd ab cd ab cd ab cd ab cd ab cd ab cd  .....
0060  ab cd ab cd ab cd ab cd ab cd ab cd ab cd ab cd  .....
0070  ab cd ab cd ab cd ab cd ab cd ab cd ab cd ab cd  .....
0080  ab cd ab cd ab cd ab cd ab cd ab cd ab cd        .....
  
```

EoMPLS VC Type-5 + CW + TE

```
Rack1R1#sh mpls l2transport vc det
Local interface: Fa1/1.10 up, line protocol up, Eth VLAN 10 up
  Interworking type is Ethernet
  Destination address: 3.3.3.3, VC ID: 102, VC status: up
  Output interface: Tu0, imposed label stack {19 20}
  Preferred path: Tunnel0, active
  Default path: ready
  Next hop: point2point
  Create time: 00:11:47, last status change time: 00:06:45
  Signaling protocol: LDP, peer 3.3.3.3:0 up
  Targeted Hello: 1.1.1.1(LDP Id) -> 3.3.3.3, LDP is UP
...
  MPLS VC labels: local 17, remote 20
```

```
!
pseudowire-class p1
  encapsulation mpls
  interworking ethernet
  preferred-path interface Tunnel0
!
interface FastEthernet1/1.10
  encapsulation dot1q 10
  xconnect 3.3.3.3 102 pw-class p1
!
```

EoMPLS VC Type-5 + bez CW + TE

No.	Time	Source	Destination	Protocol	Length	Info
23	11.119836	10.1.45.4	224.0.0.5	OSPF	116	Hello Packet
24	11.311686	4.4.4.4	5.5.5.5	ICMP	136	Echo (ping) request
25	11.365584	5.5.5.5	4.4.4.4	ICMP	132	Echo (ping) reply
26	11.387124	4.4.4.4	5.5.5.5	ICMP	136	Echo (ping) request

```

.....
> Frame 24: 136 bytes on wire (1088 bits), 136 bytes captured (1088 bits)
> Ethernet II, Src: ca:00:07:00:00:1c (ca:00:07:00:00:1c), Dst: ca:01:07:00:00:1c (ca:01:07:00:00:1c)
> MultiProtocol Label Switching Header, Label: 19, Exp: 0, S: 0, TTL: 255
▼ MultiProtocol Label Switching Header, Label: 21, Exp: 0, S: 1, TTL: 255
  MPLS Label: 21
  MPLS Experimental Bits: 0
  MPLS Bottom Of Label Stack: 1
  MPLS TTL: 255
▼ Ethernet II, Src: cc:03:07:01:00:00 (cc:03:07:01:00:00), Dst: cc:04:07:01:00:00 (cc:04:07:01:00:00)
  > Destination: cc:04:07:01:00:00 (cc:04:07:01:00:00)
  > Source: cc:03:07:01:00:00 (cc:03:07:01:00:00)
  Type: IP (0x0800)
> Internet Protocol Version 4, Src: 4.4.4.4 (4.4.4.4), Dst: 5.5.5.5 (5.5.5.5)
> Internet Control Message Protocol
  
```

```

.....
0000  ca 01 07 00 00 1c ca 00 07 00 00 1c 88 47 00 01  .....G..
0010  30 ff 00 01 51 ff cc 04 07 01 00 00 cc 03 07 01  0...Q..
0020  00 00 08 00 45 00 00 64 00 19 00 00 ff 01 a9 6e  ....E..d .....n
0030  04 04 04 04 05 05 05 05 08 00 f0 6d 00 05 00 00  .....m....
0040  00 00 00 00 00 2f 8d a8 ab cd ab cd ab cd ab cd  ...../..
0050  ab cd ab cd ab cd ab cd ab cd ab cd ab cd ab cd  .....
0060  ab cd ab cd ab cd ab cd ab cd ab cd ab cd ab cd  .....
0070  ab cd ab cd ab cd ab cd ab cd ab cd ab cd ab cd  .....
  
```

EoMPLS VC Type-5 + bez CW + TE

```
Rack1R1#sh mpls l2transport vc det
Local interface: Fa1/1.10 up, line protocol up, Eth VLAN 10 up
  Interworking type is Ethernet
  Destination address: 3.3.3.3, VC ID: 102, VC status: up
  Output interface: Tu0, imposed label stack {19 21}
  Preferred path: Tunnel0, active
  Default path: ready
  Next hop: point2point
  Create time: 00:26:28, last status change time: 00:26:15
  Signaling protocol: LDP, peer 3.3.3.3:0 up
  Targeted Hello: 1.1.1.1(LDP Id) -> 3.3.3.3, LDP is UP
  Status TLV support (local/remote) : enabled/supported
..
MPLS VC labels: local 16, remote 21
MTU: local 1500, remote 1500
Control word: off

!
pseudowire-class p1
  encapsulation mpls
  interworking ethernet
  no control-word
  preferred-path interface Tunnel0
!
interface FastEthernet1/1.10
  encapsulation dot1q 10
  xconnect 3.3.3.3 102 pw-class p1
!
```

EoMPLS VC Type-4 + CW

No.	Time	Source	Destination	Protocol	Length	Info
50	20.593357	10.1.12.1	224.0.0.2	LDP	76	Hello Message
51	20.679188	4.4.4.4	5.5.5.5	ICMP	144	Echo (ping) request id=
52	20.732902	5.5.5.5	4.4.4.4	ICMP	140	Echo (ping) reply id=
53	20.764502	4.4.4.4	5.5.5.5	ICMP	144	Echo (ping) request id=

```

▶ Frame 51: 144 bytes on wire (1152 bits), 144 bytes captured (1152 bits)
▶ Ethernet II, Src: ca:0c:0a:c7:00:1c (ca:0c:0a:c7:00:1c), Dst: ca:0d:0a:c7:00:1c (ca:0d:0a:c7:00:1c)
▶ MultiProtocol Label Switching Header, Label: 19, Exp: 0, S: 0, TTL: 255
▶ MultiProtocol Label Switching Header, Label: 21, Exp: 0, S: 1, TTL: 255
▼ PW Ethernet Control Word
  Sequence Number: 0
▼ Ethernet II (VLAN tagged), Src: ca:0f:0a:c9:00:1d (ca:0f:0a:c9:00:1d), Dst: ca:10:0a:c9:00:1d (ca:10:0a:c9:00:1d)
  ▶ Destination: ca:10:0a:c9:00:1d (ca:10:0a:c9:00:1d)
  ▶ Source: ca:0f:0a:c9:00:1d (ca:0f:0a:c9:00:1d)
  ▶ VLAN tag: VLAN=10, Priority=Best Effort (default)
    Type: IP (0x0800)
▶ Internet Protocol Version 4, Src: 4.4.4.4 (4.4.4.4), Dst: 5.5.5.5 (5.5.5.5)
▶ Internet Control Message Protocol
  
```

```

0020  ca 0f 0a c9 00 1d 81 00 00 0a 08 00 45 00 00 64  .....E..d
0030  00 00 00 00 ff 01 a9 87 04 04 04 04 05 05 05 05  .....
0040  08 00 14 1f 00 00 00 00 00 00 00 00 07 6a 24  .....j$
0050  ab cd ab cd ab cd ab cd ab cd ab cd ab cd ab cd  .....
0060  ab cd ab cd ab cd ab cd ab cd ab cd ab cd ab cd  .....
0070  ab cd ab cd ab cd ab cd ab cd ab cd ab cd ab cd  .....
0080  ab cd ab cd ab cd ab cd ab cd ab cd ab cd ab cd  .....
  
```

EoMPLS VC Type-4 + CW

```
Rack1R1#sh mpls l2transport vc det
Local interface: Fa1/1.10 up, line protocol up, Eth VLAN 10 up
  Destination address: 3.3.3.3, VC ID: 102, VC status: up
  Output interface: Fa1/0, imposed label stack {19 21}
  Preferred path: not configured
  Default path: active
  Next hop: 10.1.12.2
  Create time: 00:00:50, last status change time: 00:00:50
  Signaling protocol: LDP, peer 3.3.3.3:0 up
  Targeted Hello: 1.1.1.1(LDP Id) -> 3.3.3.3, LDP is UP
  Status TLV support (local/remote) : enabled/supported
```

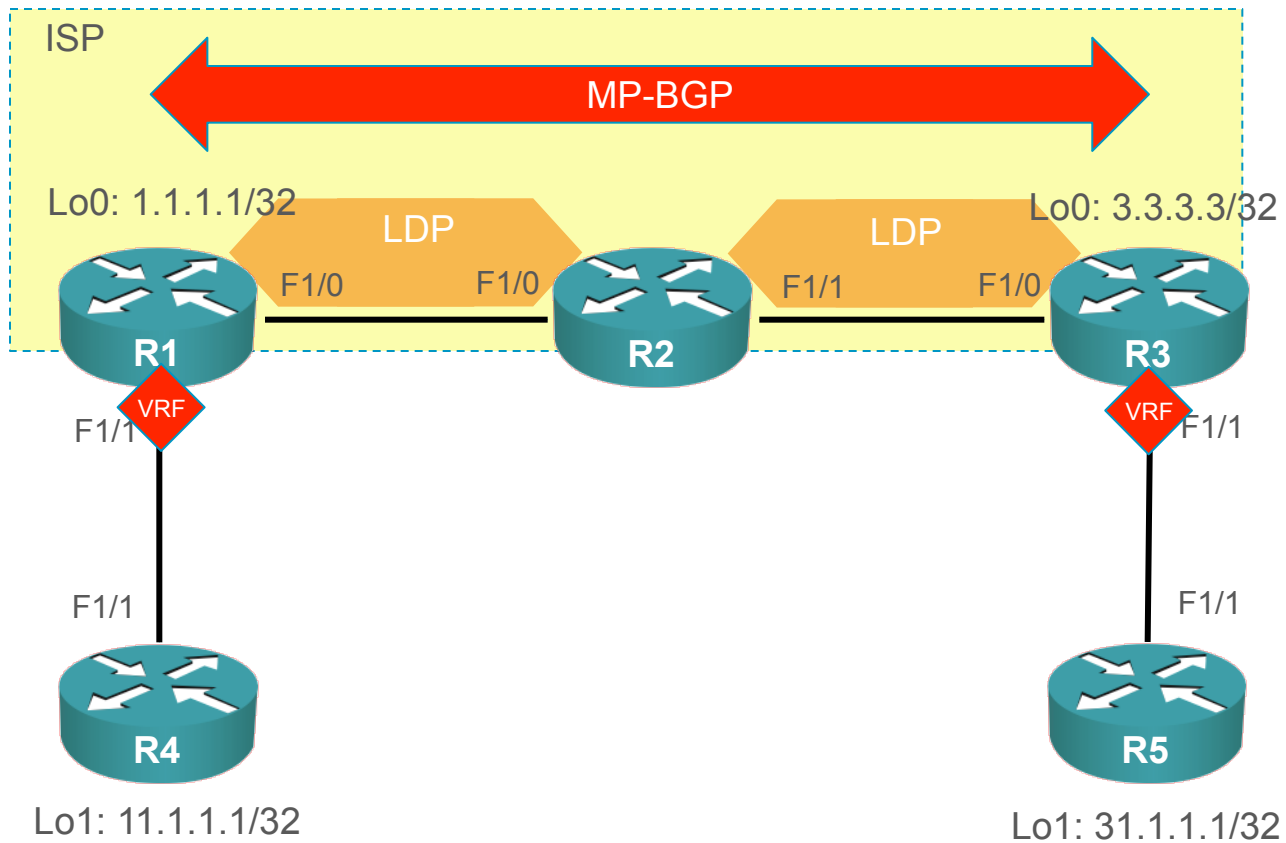
```
...
MPLS VC labels: local 22, remote 21
Group ID: local 0, remote 0
MTU: local 1500, remote 1500
```

```
Rack1R2#sh mpls for
```

Local Label	Outgoing Label	Prefix or Tunnel Id	Bytes Switched	Outgoing interface	Next Hop
18	[T] Pop Label	1.1.1.1/32	13628	Tu0	point2point
19	explicit-n	3.3.3.3/32	13581	Fa1/1	10.1.23.3

```
!
pseudowire-class p2
  encapsulation mpls
  interworking vlan
!
interface FastEthernet1/1.10
  encapsulation dot1q 10
  xconnect 3.3.3.3 102 pw-class p2
!
```

Usługa L3VPN



Usługa L3VPN

No.	Time	Source	Destination	Protocol	Length	Info
12	3.007889	11.1.1.1	31.1.1.1	ICMP	122	Echo (ping) request
13	3.039939	31.1.1.1	11.1.1.1	ICMP	118	Echo (ping) reply
14	3.050626	11.1.1.1	31.1.1.1	ICMP	122	Echo (ping) request
15	3.082476	31.1.1.1	11.1.1.1	ICMP	118	Echo (ping) reply

```

> Frame 12: 122 bytes on wire (976 bits), 122 bytes captured (976 bits)
> Ethernet II, Src: ca:0c:0a:c7:00:1c (ca:0c:0a:c7:00:1c), Dst: ca:0d:0a:c7:00:1c (ca:0d:0a:c7:00:1c)
> MultiProtocol Label Switching Header, Label: 19, Exp: 0, S: 0, TTL: 255
▼ MultiProtocol Label Switching Header, Label: 23, Exp: 0, S: 1, TTL: 255
  MPLS Label: 23
  MPLS Experimental Bits: 0
  MPLS Bottom Of Label Stack: 1
  MPLS TTL: 255
> Internet Protocol Version 4, Src: 11.1.1.1 (11.1.1.1), Dst: 31.1.1.1 (31.1.1.1)
> Internet Control Message Protocol
  
```

```

0010  30 ff 00 01 71 ff 45 00 00 64 00 0b 00 00 ff 01  0..q.E. .d.....
0020  8f 8a 0b 01 01 01 1f 01 01 01 08 00 fc 68 00 02  .....h..
0030  00 01 00 00 00 00 00 1e 81 c0 ab cd ab cd ab cd  .....
0040  ab cd ab cd ab cd ab cd ab cd ab cd ab cd ab cd  .....
0050  ab cd ab cd ab cd ab cd ab cd ab cd ab cd ab cd  .....
0060  ab cd ab cd ab cd ab cd ab cd ab cd ab cd ab cd  .....
0070  ab cd ab cd ab cd ab cd ab cd ab cd ab cd ab cd  .....
  
```

L3VPN

```
Rack1R1#sh ip cef vrf aa 31.1.1.1
31.1.1.0/30
  nexthop 10.1.12.2 FastEthernet1/0 label 19 23
```

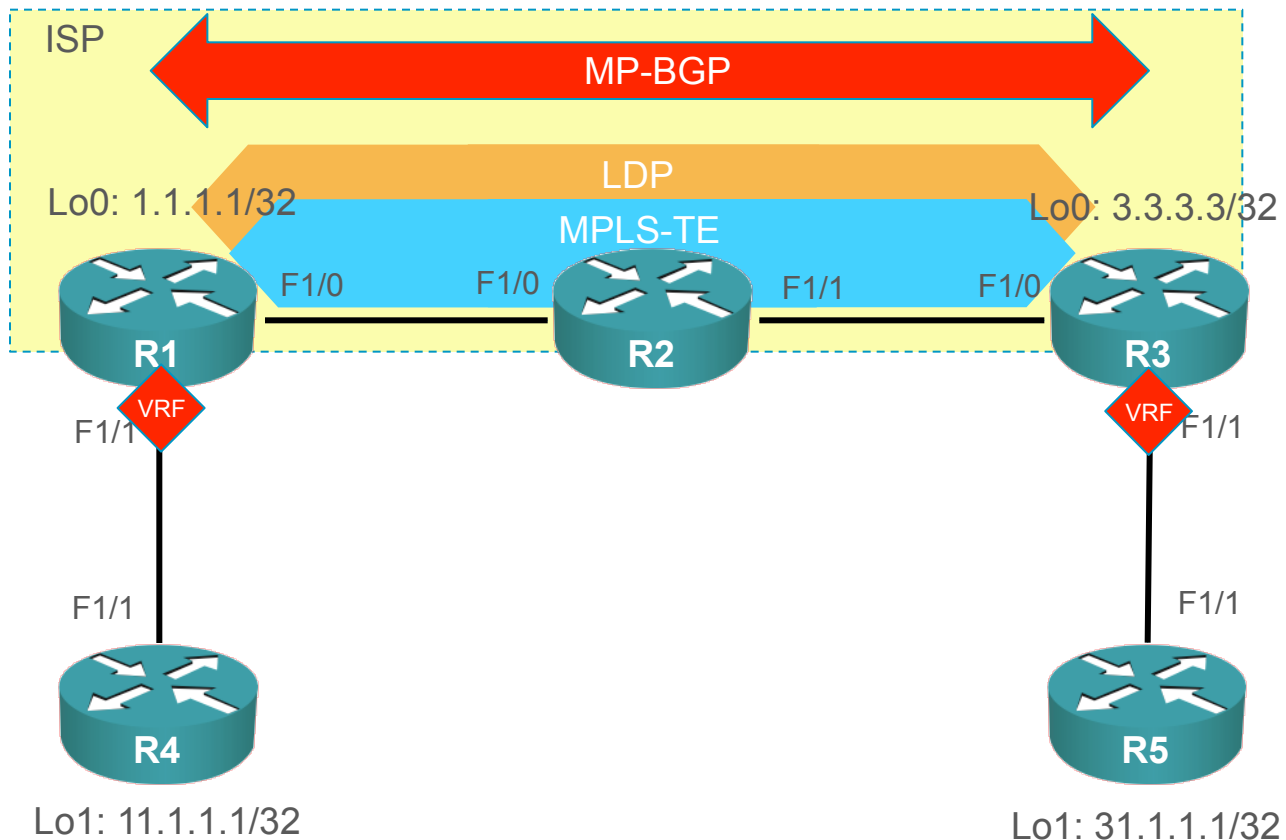
```
Rack1R1#sh ip bgp vpnv4 all labels
  Network          Next Hop      In label/Out label
Route Distinguisher: 1:1 (aa)
  11.1.1.0/30      0.0.0.0       21/nolabel(aa)
  31.1.1.0/30      3.3.3.3       nolabel/23
```

```
Rack1R1#sh mpls for
Local      Outgoing      Prefix          Bytes Label      Outgoing      Next Hop
Label      Label          or Tunnel Id    Switched          interface
19         19            3.3.3.3/32      0                 Fa1/0         10.1.12.2
```

```
!
router bgp 13
  bgp log-neighbor-changes
  neighbor 3.3.3.3 remote-as 13
  neighbor 3.3.3.3 update-source Loopback0
  !
  address-family vpnv4
    neighbor 3.3.3.3 activate
    neighbor 3.3.3.3 send-community extended
  exit-address-family
  !
  address-family ipv4 vrf aa
    no synchronization
    redistribute connected
  exit-address-family
!
```

L3VPN + TE

- Tunel TE między R1, a R3.
- LDP explicit-null uruchomiony w tunelu TE.



L3VPN + TE

No.	Time	Source	Destination	Protocol	Length	Info
39	19.067973	31.1.1.1	11.1.1.1	ICMP	118	Echo (ping) reply
40	19.078714	11.1.1.1	31.1.1.1	ICMP	126	Echo (ping) request
41	19.110846	31.1.1.1	11.1.1.1	ICMP	118	Echo (ping) reply
42	19.121920	11.1.1.1	31.1.1.1	ICMP	126	Echo (ping) request
43	19.154053	31.1.1.1	11.1.1.1	ICMP	118	Echo (ping) reply

```

.....
> Frame 40: 126 bytes on wire (1008 bits), 126 bytes captured (1008 bits)
> Ethernet II, Src: ca:0c:0a:c7:00:1c (ca:0c:0a:c7:00:1c), Dst: ca:0d:0a:c7:00:1c (ca:0d:0a:c7:00:1c)
> MultiProtocol Label Switching Header, Label: 17, Exp: 0, S: 0, TTL: 255
> MultiProtocol Label Switching Header, Label: 0 (IPv4 Explicit-Null), Exp: 0, S: 0, TTL: 255
  MPLS Label: 0 (IPv4 Explicit-Null)
  MPLS Experimental Bits: 0
  MPLS Bottom Of Label Stack: 0
  MPLS TTL: 255
> MultiProtocol Label Switching Header, Label: 23, Exp: 0, S: 1, TTL: 255
> Internet Protocol Version 4, Src: 11.1.1.1 (11.1.1.1), Dst: 31.1.1.1 (31.1.1.1)
> Internet Control Message Protocol
  
```

```

.....
0010  00 ff 00 00 00 ff 00 01 71 ff 45 00 00 64 00 11  ...... q.E..d..
0020  00 00 ff 01 8f 84 0b 01 01 01 1f 01 01 01 08 00  .....,.....
0030  aa 98 00 03 00 02 00 00 00 00 00 28 d3 84 ab cd  .....,.....
0040  ab cd ab cd ab cd ab cd ab cd ab cd ab cd ab cd  .....,.....
0050  ab cd ab cd ab cd ab cd ab cd ab cd ab cd ab cd  .....,.....
0060  ab cd ab cd ab cd ab cd ab cd ab cd ab cd ab cd  .....,.....
0070  ab cd ab cd ab cd ab cd ab cd ab cd ab cd ab cd  .....,.....
  
```

Rozgłoszenie etykiety TE

No.	Time	Source	Destination	Protoc	Length	Info
50	20.894592	10.1.12.2	224.0.0.5	OSPF	94	Hello Packet
16	8.346441	1.1.1.1	3.3.3.3	RSVP	242	PATH Message. SESSION: IPv4-LSP, Destination 3.3.3.3,
17	8.432331	10.1.12.2	10.1.12.1	RSVP	142	RESV Message. SESSION: IPv4-LSP, Destination 3.3.3.3,
35	14.866332	2.2.2.2	1.1.1.1	RSVP	226	PATH Message. SESSION: IPv4-LSP, Destination 1.1.1.1,

```

.....
▶ Frame 17: 142 bytes on wire (1136 bits), 142 bytes captured (1136 bits)
▶ Ethernet II, Src: ca:01:01:b2:00:1c (ca:01:01:b2:00:1c), Dst: ca:00:01:b2:00:1c (ca:00:01:b2:00:1c)
▶ Internet Protocol Version 4, Src: 10.1.12.2 (10.1.12.2), Dst: 10.1.12.1 (10.1.12.1)
▼ Resource ReserVation Protocol (RSVP): RESV Message. SESSION: IPv4-LSP, Destination 3.3.3.3, Tunnel ID 0, Ext ID 1010101. FILTERSPEC: IPv4-LSP, Tunnel ID 0, Ext ID 1010101.
  ▶ RSVP Header. RESV Message.
  ▶ SESSION: IPv4-LSP, Destination 3.3.3.3, Tunnel ID 0, Ext ID 1010101.
  ▶ HOP: IPv4, 10.1.12.2
  ▶ TIME VALUES: 30000 ms
  ▶ STYLE: Shared-Explicit (18)
  ▶ FLOWSPEC: Controlled Load: Token Bucket, 0 bytes/sec.
  ▶ FILTERSPEC: IPv4-LSP, Tunnel Source: 1.1.1.1, LSP ID: 26.
▼ LABEL: 17
  Length: 8
  Object class: LABEL object (16)
  C-type: 1 (Packet Label)
  Label: 17
  
```

```

.....
0060 00 06 7f 00 00 05 00 00 00 00 44 7a 00 00 00 00  ....Dz....
0070 00 00 00 00 00 00 00 00 05 dc 00 0c 0a 07 01 01  ....
0080 01 01 00 00 00 1a 00 08 10 01 00 00 00 11  ....
  
```

Rozgłoszenie etykiety VPN

No.	Time	Source	Destination	Protocol	Length	Info
33	8.790404	3.3.3.3	1.1.1.1	BGP	73	KEEPALIVE Message
34	8.877352	3.3.3.3	1.1.1.1	BGP	73	KEEPALIVE Message
35	8.888443	3.3.3.3	1.1.1.1	BGP	277	UPDATE Message, UPDATE Message, UPDATE Message
36	8.899269	3.3.3.3	1.1.1.1	BGP	171	UPDATE Message, UPDATE Message

▶ Ethernet II, Src: ca:01:01:b2:00:1c (ca:01:01:b2:00:1c), Dst: ca:00:01:b2:00:1c (ca:00:01:b2:00:1c)
▶ Internet Protocol Version 4, Src: 3.3.3.3 (3.3.3.3), Dst: 1.1.1.1 (1.1.1.1)
▶ Transmission Control Protocol, Src Port: bgp (179), Dst Port: 44060 (44060), Seq: 121, Ack: 102, Len: 223
▼ Border Gateway Protocol
 ▼ UPDATE Message

Pakiet skrócony

▼ MP_REACH_NLRI (48 bytes)
 ▶ Flags: 0x80 (Optional, Non-transitive, Complete)
 Type code: MP_REACH_NLRI (14)
 Length: 45 bytes
 Address family: IPv4 (1)
 Subsequent address family identifier: Labeled VPN Unicast (128)
 ▶ Next hop network address (12 bytes)
 Subnetwork points of attachment: 0
 ▼ Network layer reachability information (28 bytes)
 ▶ Label Stack=22 (bottom) RD=1:1, IPv4=0.0.0.0/0
 ▼ Label Stack=23 (bottom) RD=1:1, IPv4=31.1.1.0/30
 MP Reach NLRI Prefix length: 118
 MP Reach NLRI Label Stack: 23 (bottom)
 MP Reach NLRI Route Distinguisher: 1:1
 MP Reach NLRI IPv4 prefix: 31.1.1.0 (31.1.1.0)

L3VPN + TE

```
Rack1R1#sh ip cef vrf aa 31.1.1.1 int
31.1.1.0/30, epoch 0, flags need ps clean, rib defined all labels, RIB[B],
refcount 5, per-destination sharing
  sources: RIB, LTE
```

```
..
output chain: label 23 label explicit-null TAG midchain out of Tunnel0
669428C0 label 17 TAG adj out of FastEthernet1/0, addr 10.1.12.2 65464100
```

```
Rack1R1#sh mpls for
Local      Outgoing  Prefix          Bytes Label    Outgoing  Next Hop
Label     Label     or Tunnel Id    Switched       interface
21      [T]  explicit-n 3.3.3.3/32      0          Tu0        point2point
```

```
Rack1R1#sh mpls traffic-eng tunnels
Name: Rack1R1_t0                               (Tunnel0) Destination: 3.3.3.3
Status:
  Admin: up           Oper: up           Path: valid        Signalling: connected
  path option 7, type dynamic (Basis for Setup, path weight 2)
..
InLabel   : -
OutLabel  : FastEthernet1/0, 17
Next Hop  : 10.1.12.2
RSVP Signalling Info:
  Src 1.1.1.1, Dst 3.3.3.3, Tun_Id 0, Tun_Instance 26
```

L3VPN + TE + QoS

No.	Time	Source	Destination	Protocol	Length	Info
4	2.235422	1.1.1.1	3.3.3.3	LDP	84	Hello Message
5	2.278415	11.1.1.1	31.1.1.1	ICMP	126	Echo (ping) request
6	2.311383	31.1.1.1	11.1.1.1	ICMP	118	Echo (ping) reply
7	2.322127	11.1.1.1	31.1.1.1	ICMP	126	Echo (ping) request

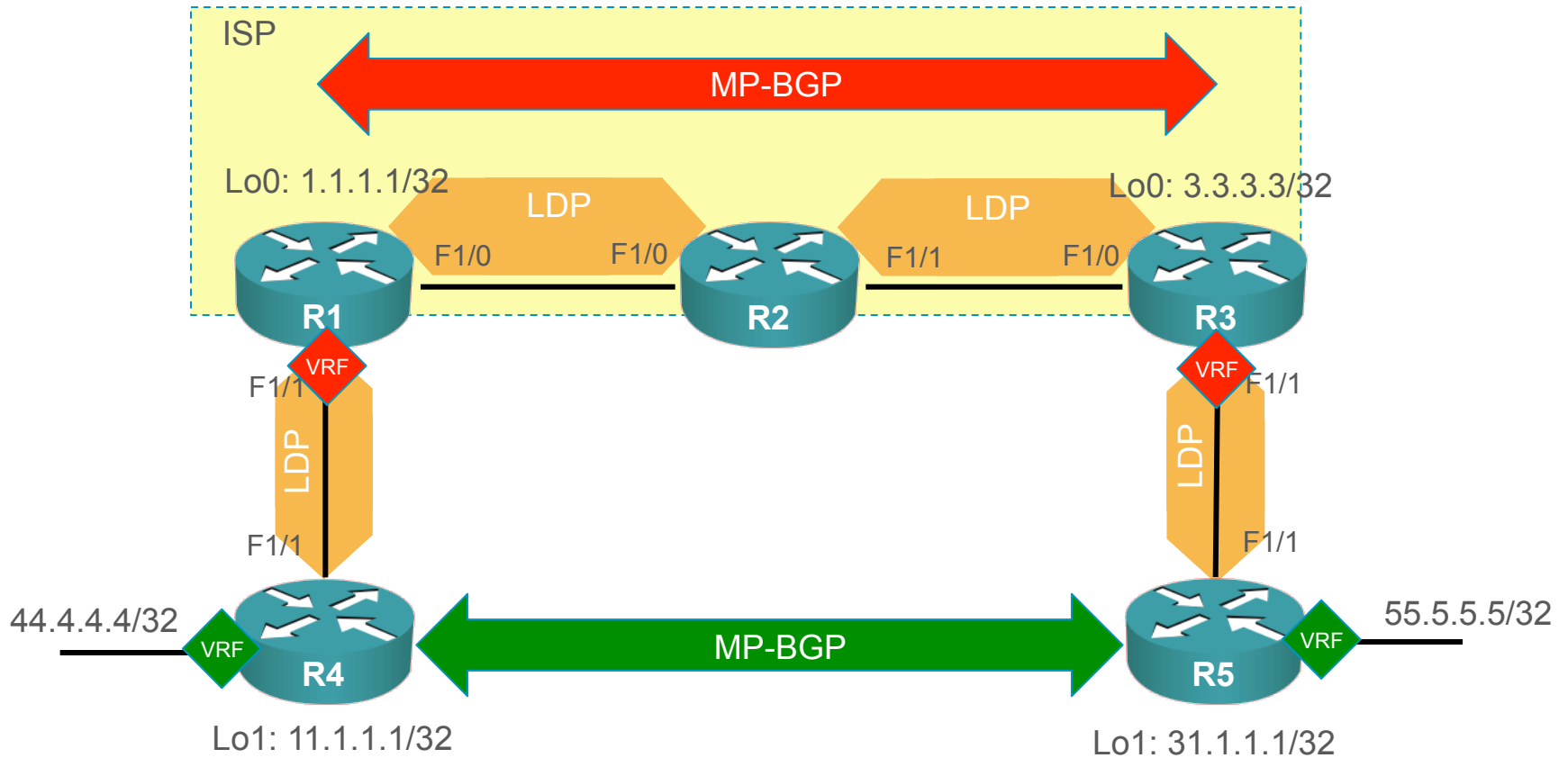
```

> Frame 5: 126 bytes on wire (1008 bits), 126 bytes captured (1008 bits)
> Ethernet II, Src: ca:00:01:b2:00:1c (ca:00:01:b2:00:1c), Dst: ca:01:01:b2:00:1c (ca:01:01:b2:00:1c)
> MultiProtocol Label Switching Header, Label: 21, Exp: 5, S: 0, TTL: 255
> MultiProtocol Label Switching Header, Label: 0 (IPv4 Explicit-Null), Exp: 5, S: 0, TTL: 255
> MultiProtocol Label Switching Header, Label: 23, Exp: 5, S: 1, TTL: 255
< Internet Protocol Version 4, Src: 11.1.1.1 (11.1.1.1), Dst: 31.1.1.1 (31.1.1.1)
  Version: 4
  Header length: 20 bytes
  > Differentiated Services Field: 0xb8 (DSCP 0x2e: Expedited Forwarding; ECN: 0x00: Not-ECT (Not ECN-Capable Transp
  Total Length: 100
  Identification: 0x0019 (25)
  > Flags: 0x00
  Fragment offset: 0
  Time to live: 255
  Protocol: ICMP (1)
  > Header checksum: 0x8ec4 [correct]
  Source: 11.1.1.1 (11.1.1.1)
  
```

```

0010  5a ff 00 00 0a ff 00 01 7b ff 45 b8 00 64 00 19  Z..... {.E}.d..
0020  00 00 ff 01 8e c4 0b 01 01 01 1f 01 01 01 08 00  .....
0030  80 9c 00 05 00 00 00 00 00 00 02 64 fb 44 ab cd  ..... ..d.D..
  
```

Carrier Supporting Carrier



Carrier Supporting Carrier

No.	Time	Source	Destination	Protocol	Length	Info
3	1.419991	10.1.12.1	224.0.0.2	LDP	76	Hello Message
4	1.517065	44.4.4.4	55.5.5.5	ICMP	126	Echo (ping) request
5	1.570900	55.5.5.5	44.4.4.4	ICMP	122	Echo (ping) reply
6	1.592952	44.4.4.4	55.5.5.5	ICMP	126	Echo (ping) request

```

▶ Frame 4: 126 bytes on wire (1008 bits), 126 bytes captured (1008 bits)
▼ Ethernet II, Src: ca:00:01:b2:00:1c (ca:00:01:b2:00:1c), Dst: ca:01:01:b2:00:1c (ca:01:01:b2:00:1c)
  ▶ Destination: ca:01:01:b2:00:1c (ca:01:01:b2:00:1c)
  ▶ Source: ca:00:01:b2:00:1c (ca:00:01:b2:00:1c)
    Type: MPLS label switched packet (0x8847)
  ▶ MultiProtocol Label Switching Header, Label: 18, Exp: 0, S: 0, TTL: 254
  ▶ MultiProtocol Label Switching Header, Label: 18, Exp: 0, S: 0, TTL: 254
  ▶ MultiProtocol Label Switching Header, Label: 16, Exp: 0, S: 1, TTL: 255
  ▶ Internet Protocol Version 4, Src: 44.4.4.4 (44.4.4.4), Dst: 55.5.5.5 (55.5.5.5)
  ▶ Internet Control Message Protocol
  
```

```

0000  ca 01 01 b2 00 1c ca 00 01 b2 00 1c 88 47 00 01  .....G..
0010  20 fe 00 01 20 fe 00 01 01 ff 45 00 00 64 00 2b  ... ..E..d+
0020  00 00 ff 01 4f 5c 2c 04 04 04 37 05 05 05 08 00  ....0\,. ..7.....
  
```

Carrier Supporting Carrier

```
Rack1R4#traceroute vrf aa 55.5.5.5 s 44.4.4.4
```

```
Type escape sequence to abort.  
Tracing the route to 55.5.5.5
```

```
 1 10.3.14.1 [MPLS: Labels 24/16 Exp 0] 452 msec 148 msec 72 msec  
 2 10.1.12.2 [MPLS: Labels 18/18/16 Exp 0] 92 msec 84 msec 84 msec  
 3 10.1.23.3 [MPLS: Labels 0/18/16 Exp 0] 84 msec 88 msec 84 msec  
 4 55.5.5.5 72 msec * 44 msec
```

```
Rack1R4#sh ip cef vrf aa 55.5.5.5  
55.5.5.5/32  
  nexthop 10.3.14.1 FastEthernet1/1.30 label 24 16
```

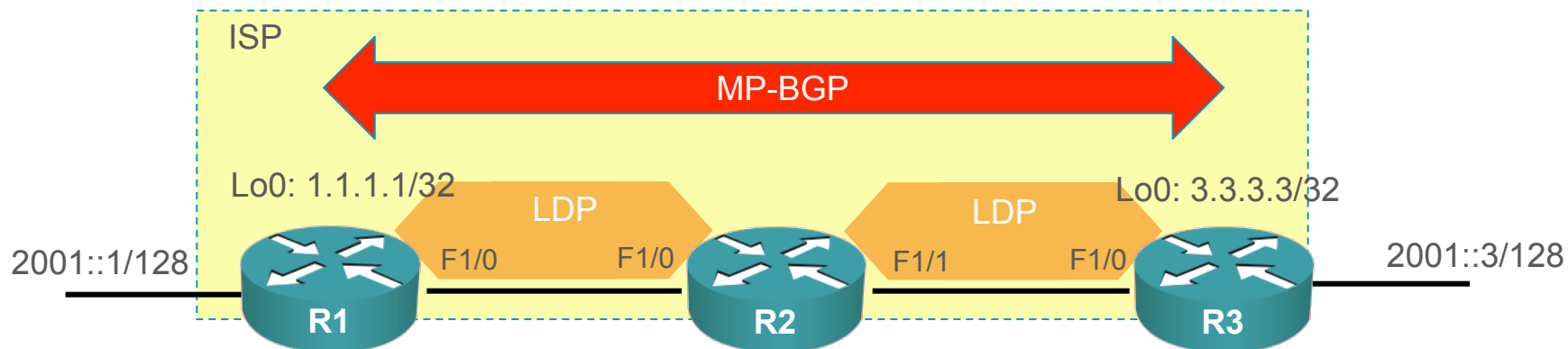
```
Rack1R1#sh ip cef vrf sp 5.5.5.5  
5.5.5.5/32  
  nexthop 10.1.12.2 FastEthernet1/0 label 18 18
```

```
Rack1R1#sh mpls for 3.3.3.3
```

Local Label	Outgoing Label	Prefix or Tunnel Id	Bytes Switched	Label	Outgoing interface	Next Hop
21	18	3.3.3.3/32	0		Fa1/0	10.1.12.2

6PE

- Sieć MPLS IPv4 między R1, a R3.
- Klienci IPv6 dołączeni do R1 oraz R3.



6PE

No.	Time	Source	Destination	Protocol	Length	Info
3	1.586581	2.2.2.2	1.1.1.1	LDP	76	Hello Message
4	1.983535	2001::1	2001::3	ICMPv6	122	Echo (ping) request
5	2.016002	2001::3	2001::1	ICMPv6	118	Echo (ping) reply ic
6	2.026982	2001::1	2001::3	ICMPv6	122	Echo (ping) request

.....

▶ Frame 4: 122 bytes on wire (976 bits), 122 bytes captured (976 bits)

▼ Ethernet II, Src: ca:00:01:b2:00:1c (ca:00:01:b2:00:1c), Dst: ca:01:01:b2:00:1c (ca:01:01:b2:00:1c)

- ▶ Destination: ca:01:01:b2:00:1c (ca:01:01:b2:00:1c)
- ▶ Source: ca:00:01:b2:00:1c (ca:00:01:b2:00:1c)

Type: MPLS label switched packet (0x8847)

- ▶ MultiProtocol Label Switching Header, Label: 18, Exp: 0, S: 0, TTL: 64
- ▶ MultiProtocol Label Switching Header, Label: 16, Exp: 0, S: 1, TTL: 64
- ▶ Internet Protocol Version 6, Src: 2001::1 (2001::1), Dst: 2001::3 (2001::3)
- ▶ Internet Control Message Protocol v6

.....

```
0000  ca 01 01 b2 00 1c ca 00 01 b2 00 1c 88 47 00 01  .....G..
0010  20 40 00 01 01 40 60 00 00 00 00 3c 3a 40 20 01  @...@`...<:@
0020  00 00 00 00 00 00 00 00 00 00 00 00 00 01 20 01  .....
0030  00 00 00 00 00 00 00 00 00 00 00 00 03 80 00    .....
0040  ad 61 05 7b 00 00 00 01 02 03 04 05 06 07 08 09  .a.{.....
0050  0a 0b 0c 0d 0e 0f 10 11 12 13 14 15 16 17 18 19  .....
0060  1a 1b 1c 1d 1e 1f 20 21 22 23 24 25 26 27 28 29  ..... ! "#$%&'()
0070  2a 2b 2c 2d 2e 2f 30 31 32 33                    *+,-./01 23
```

6PE

No.	Time	Source	Destination	Protoc	Length	Info
35	8.888443	3.3.3.3	1.1.1.1	BGP	277	UPDATE Message, UPDATE Message, UPDATE Message
36	8.899269	3.3.3.3	1.1.1.1	BGP	171	UPDATE Message, UPDATE Message
37	8.909460	3.3.3.3	1.1.1.1	BGP	77	UPDATE Message
42	9.707178	1.1.1.1	3.3.3.3	BGP	77	KFFPAI TVF Message

▶ Frame 36: 171 bytes on wire (1368 bits), 171 bytes captured (1368 bits)
▶ Ethernet II, Src: ca:01:01:b2:00:1c (ca:01:01:b2:00:1c), Dst: ca:00:01:b2:00:1c (ca:00:01:b2:00:1c)
▶ Internet Protocol Version 4, Src: 3.3.3.3 (3.3.3.3), Dst: 1.1.1.1 (1.1.1.1)
▶ Transmission Control Protocol, Src Port: bgp (179), Dst Port: 44060 (44060), Seq: 344, Ack: 102, Len: 117

Border Gateway Protocol

UPDATE Message

Marker: 16 bytes

Length: 88 bytes

Type: UPDATE Message (2)

Unfeasible routes length: 0 bytes

Total path attribute length: 65 bytes

Path attributes

▶ ORIGIN: INCOMPLETE (4 bytes)

▶ AS_PATH: empty (3 bytes)

▶ MULTI_EXIT_DISC: 0 (7 bytes)

▶ LOCAL_PREF: 100 (7 bytes)

MP_REACH_NLRI (44 bytes)

▶ Flags: 0x80 (Optional, Non-transitive, Complete)

Type code: MP_REACH_NLRI (14)

Length: 41 bytes

Address family: IPv6 (2)

Subsequent address family identifier: Labeled Unicast (4)

Next hop network address (16 bytes)

Next hop: ::ffff:3.3.3.3 (16)

Subnetwork points of attachment: 0

Network layer reachability information (20 bytes)

Label Stack=16 (bottom), IPv6=2001::3/128

6PE

```
Rack1R1#sh ipv6 cef 2001::3/128
2001::3/128
  nexthop 10.1.12.2 FastEthernet1/0 label 18 16
```

```
Rack1R1#sh mpls for
Local      Outgoing  Prefix          Bytes Label  Outgoing  Next Hop
Label      Label     or Tunnel Id    Switched     interface
21         18        3.3.3.3/32      0            Fa1/0     10.1.12.2
```

```
Rack1R1#sh bgp ipv6 uni la
Network    Next Hop      In label/Out label
2001::1/128  ::           23/nolabel
2001::3/128  ::FFFF:3.3.3.3 nolabel/16
```

```
R1:
!
router bgp 13
  neighbor 3.3.3.3 remote-as 13
  neighbor 3.3.3.3 update-source Loopback0
!
  address-family ipv6
    redistribute connected
    no synchronization
    neighbor 3.3.3.3 activate
    neighbor 3.3.3.3 send-label
  !
```

Quiz

- Której enkapsulacji nie można uzyskać?

1. ETH | TE | TE | VPNv4 | IP
2. ETH | LDP | VC | LDP | VC | ETH | IP
3. ETH | TE | VPNv4 | VPNv4 | IP
4. ETH | IP | GRE | VPNv4 | IP
5. ETH | TE | LDP | IP
6. ETH | LDP | TE | IP
7. ETH | TE | IP

Podsumowanie karty dań

- Najczęściej spotykane stosy etykiet

ETH | LDP | VC | ETH | IP – usługa L2VPN

ETH | LDP | VPNv4 | IP – usługa L3VPN

ETH | TE | VPNv4 | IP – L3VPN poprzez tunel TE

ETH | TE | VC | CW | ETH | IP – L2VPN poprzez tunel

Pytania i odpowiedzi

742	470.276787	4.4.4.4	5.5.5.5
743	470.320227	5.5.5.5	4.4.4.4
744	470.342060	4.4.4.4	5.5.5.5

Frame 742: 140 bytes on wire (1120 bits), 140 bytes captured (1120 bits)
Ethernet II, Src: ca:00:07:00:00:1c (ca:00:07:00:00:1c), Dst: ca:01:07:00:00:00
MultiProtocol Label Switching Header, Label: 19, Exp: 0, S: 0, TTL: 255
MultiProtocol Label Switching Header, Label: 20, Exp: 0, S: 1, TTL: 255
PW Ethernet Control Word
Ethernet II, Src: cc:03:07:01:00:00 (cc:03:07:01:00:00), Dst: cc:04:07:01:00:00
‣ Destination: cc:04:07:01:00:00 (cc:04:07:01:00:00)
‣ Source: cc:03:07:01:00:00 (cc:03:07:01:00:00)
Type: IP (0x0800)
Internet Protocol Version 4, Src: 4.4.4.4 (4.4.4.4), Dst: 5.5.5.5 (5.5.5.5)
Internet Control Message Protocol

10	30 ff 00 01 41 ff 00 00	00 00 cc 04 07 01 00 00	0...A... ..
20	cc 03 07 01 00 00 08 00	45 00 00 64 00 0f 00 00 E..d....
30	ff 01 a9 78 04 04 04 04	05 05 05 05 08 00 87 a6	...x.... ..
40	00 03 00 00 00 00 00 00	00 10 f6 90 ab cd ab cd
50	ab cd ab cd ab cd ab cd	ab cd ab cd ab cd ab cd

