Radio Aware Routing and Dynamic Link Exchange Protocol

This chapter contains the following sections:

Overview of Radio Aware Routing

Introduction

Relief workers, soldiers, public safety personnel, and others need the right information, in the right place, at the right time, wherever they are located. Mobile ad hoc networks are emerging to address these needs. The IETF request for comment, RFC RFC5578, defines a PPP-over-Ethernet (PPPoE) based mechanism for integrating IP routers and mobile radios in ad hoc networks, enabling faster convergence, more efficient route selection, and better performance for delaysensitive traffic.

Radio-Aware Routing (RAR) is a mechanism that uses radios to interact with the routing protocol OSPFv3/EIGRP to signal the appearance, disappearance, and link conditions of one-hop routing neighbors.

In large mobile networks, connections to the routing neighbors are often interrupted due to distance and radio obstructions. When these signals do not reach the routing protocols, protocol timers are used to update the status of a neighbor. Routing protocols have lengthy timers, which is not recommended in mobile networks.

The RAR feature is supported on the Cisco ESR6300 Embedded Series Router.

Mobile Ad Hoc Networking (MANET)

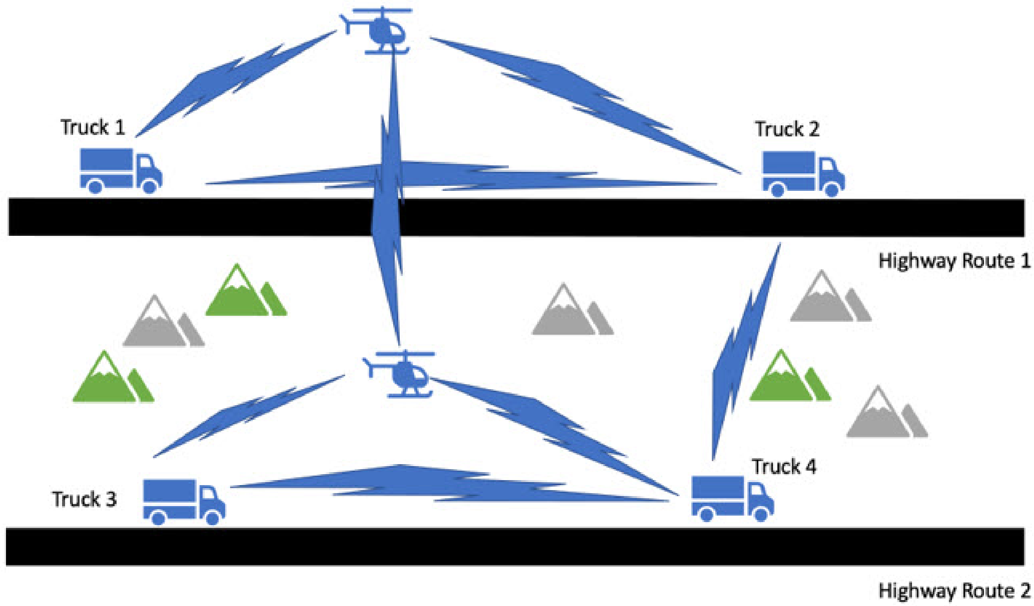
Mobile ad hoc networks are emerging as a means for delivering the benefits of IP networking to users operating beyond the reach of a fixed network. In ad hoc networks, mobile nodes associate on an extemporaneous or ad hoc basis. Ad hoc networks have numerous distinguishing characteristics when compared to conventional networking solutions:

- **`Self-forming`** — Nodes that come within radio range of each other can establish a network association without any pre-configuration or manual intervention.
- **`Self-healing`** — Nodes can join or leave rapidly without affecting operation of the remaining nodes.
- **`No infrastructure`** — In an ad hoc network, mobile nodes form their own network, and essentially become their own infrastructure.
- **`Peer to peer`** — Traditional networks typically support end systems operating in client-server mode. In an ad hoc network, mobile nodes can communicate and exchange information without prior arrangement and without reliance on centralized resources.
- **`Predominantly wireless`** — Historically networks have been mostly wired, and enhanced or extended through wireless access. The ad hoc environment is essentially wireless, but can be extended to support wired resources.
- **`Highly dynamic`** — Mobile nodes are in continuous motion and ad hoc networking topologies are constantly changing.

Collectively, these characteristics will enable ad hoc networks to deliver timely information to a new and underserved class of users. Ad hoc networking solutions can be applied to virtually any scenario that involves a cadre of highly mobile users or platforms (which may include stationary devices as well), a strong need to share IP-based information, and an environment in which fixed infrastructure is impractical, impaired, or impossible.

A Real-World Problem Description

Consider the following diagram:



The above network is a voice, video, data network between moving vehicles that consists of both ground and air vehicles, hence the network is mobile and it is a peer to peer mesh that changes as topographical obstructions are encountered. This is where we get the term mobile ad hock network or MANET for short.

In the scenario in the drawing, all 4 trucks always have connectivity with the helicopters that are flying over the same road. The two helicopters always have line of sight and will always have a connection between each other. The trucks may even be able to connect to the other helicopter or a truck on the opposite road when conditions are favorable.

Here we see that the path between trucks 1 and 3 are completely blocked. The path between Truck 2 and 4 is about to be blocked.

Our existing routing protocols such as OSPFv3 and EIGRP need to adjust its path metrics very quickly to maintain a cohesive operational network. The routing protocol also needs a way to get that information from the radios and that requires a radio to router protocol that is delivered by Cisco Radio Aware Routing in the form of two open protocols:

- PPP over Ethernet (PPPoE)
- Dynamic Link Exchange Protocol (DLEP)

Both protocols are discussed later in this document.

Benefits of Radio Aware Routing

The Radio Aware Routing feature offers the following benefits:

- Provides faster network convergence through immediate recognition of changes.
- Enables routing for failing or fading radio links.
- Allows easy routing between line-of-sight and non-line-of-sight paths.

- Provides faster convergence and optimal route selection so that delay-sensitive traffic, such as voice and video, is not disrupted
- Provides efficient radio resources and bandwidth usage.
- Reduces impact on the radio links by performing congestion control in the router.
- Allows route selection based on radio power conservation.
- Enables decoupling of the routing and radio functionalities.
- Provides simple Ethernet connection to RFC 5578 and DLEP compliant radios.

Restrictions and Limitations

The Radio Aware Routing and DLEP features have the following restrictions and limitations:

- Multicast traffic is not supported with DLEP, but is supported with PPPOE.
- DLEP does not support IPv6
- Cisco High Availability (HA) technology is not supported.
- Requires the Network Advantage license.

Note There is a condition that exists with DLEP that is not unique to the ESR6300. An ARP which has been learned on a VMI does not get deleted when the mapped physical interface goes down.

Note Previous releases of IOS XE offered support for IPv4 unicast traffic over an IPv4 DLEP session. IOS XE 17.12.1a provides support for IPv6 unicast, IPv4 multicast and IPv6 multicast over an IPv4 DLEP. See the DLEP IPv6 Unicastsection.

Performance

The Radio Aware Routing feature has the ability to support a maximum of 10 neighbors per radio or VMI interface, and a total of 30 to 40 neighbors.

System Components

The Radio Aware Routing (RAR) feature is implemented using the MANET (Mobile adhoc network) infrastructure comprising of different components such as PPPoE, Virtual multipoint interface (VMI), QoS, routing protocol interface and RAR protocols.

Point-to-Point Protocol over Ethernet PPPoE or PPPoE

PPPoE is a well-defined communication mechanism between the client and the server. In the RAR implementation, radio takes the role of the PPPoE client and router takes the role of the PPPoE server. This allows a loose coupling of radio and router, while providing a well-defined and predictable communication mechanism.

As PPPoE is a session or a connection oriented protocol, it extends the point-to-point radio frequency (RF) link from an external radio to an IOS router.

PPPoE Extensions

PPPoE extensions are used when the router communicates with the radio. In the Cisco IOS implementation of PPPoE, each individual session is represented by virtual access interface (connectivity to a radio neighbor) on which, QoS can be applied with these PPPoE extensions.

RFC5578 provides extensions to PPPoE to support credit-based flow control and session-based real time link metrics, which are very useful for connections with variable bandwidth and limited buffering capabilities (such as radio links).

Virtual Multipoint Interface (VMI)

Though PPPoE Extensions provides most of the setup to communicate between a router and a radio, VMI addresses the need to manage and translate events that higher layers (example, routing protocols) consume. In addition, VMI operates in the Bypass mode.

In Bypass mode, every Virtual Access Interface (VAI) representing a radio neighbor is exposed to routing protocols OSPFv3 and EIGRP, so that, the routing protocol directly communicates with the respective VAI for both unicast and multicast routing protocol traffic.

Note DLEP only supports aggregate mode. The preferred mode for PPPOE is bypass.

In Aggregate mode, VMI is exposed to the routing protocols (OSPF) so that the routing protocols can leverage VMI for their optimum efficiency. When the network neighbors are viewed as a collection of networks on a point-to-multipoint link with broadcast and multicast capability at VMI, VMI helps in aggregating the multiple virtual access interfaces created from PPPoE. VMI presents a single multi access layer 2 broadcast capable interface. The VMI layer re-directs unicast routing protocol traffic to the appropriate P2P link (Virtual-Access interface), and replicates any Multicast/Broadcast traffic that needs to flow. Since the routing protocol communicates to a single interface, the size of the topology database is reduced, without impacting the integrity of the network.

Radio Aware Routing Topology

This section provides a high level description on how RAR, MANETs, and PPPoE work together.

About MANETs

Mobile Ad Hoc Networks (MANETs) for device-to-radio communications address the challenges faced when merging IP routing and mobile radio communications in ad hoc networking applications.

Through the device-to-radio link, the radio can inform the device immediately when a node joins or leaves, and this enables the device to recognize topology changes more quickly than if it had to rely on timers. Without this link-status notification from the radio, the device would likely time out while waiting for traffic. The link-status notification from the radio enables the device to respond faster to network topology changes. Metric information regarding the quality of a link is passed between the device and radio, enabling the device to more intelligently decide on which link to use.

With the link-status signaling provided by the device-to-radio link, applications such as voice and video work better because outages caused by topology changes are reduced or eliminated. Sessions are more stable and remain active longer.

Cross-layer feedback for device-to-radio integration of Radio-Aware Routing (RAR) takes advantage of the functions defined in RFC 5578. The RFC 5578 is an Internet Engineering Task Force (IETF) standard that defines PPP over Ethernet (PPPoE) extensions for Ethernet-based communications between a device and a mobile radio, that operates in a variable-bandwidth environment and has limited buffering capabilities. These extensions provide a PPPoE session-based mechanism for sharing radio network status such as link-quality metrics and establishing flow control between a device and an RAR-compliant radio.

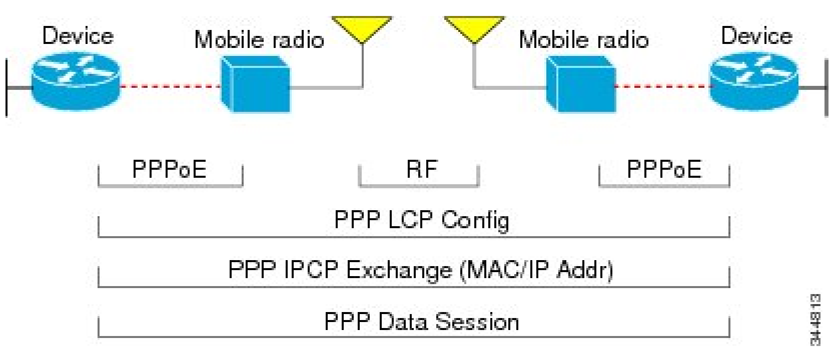
An RAR-compliant radio initiates a Layer 2 PPPoE session with its adjacent device on behalf of every device and radio neighbor discovered in the network. These Layer 2 sessions are the means by which radio network status for each neighbor link is reported to the device. The radio establishes the correspondence between each PPPoE session and each link to a neighbor.

PPPoE Interfaces for Mobile Radio Communications

The Mobile Ad Hoc Network (MANET) implementation uses PPP over Ethernet (PPPoE) sessions to enable intranodal communications between a device and its partner radio. Each radio initiates the PPPoE session as soon as the radio establishes a radio link to another radio. After the PPPoE sessions are active, a PPP session is established end-to-end (device-to-device). This is duplicated each time a radio establishes a new radio link. The virtual multipoint interface (VMI) on the device can aggregate multiple PPPoE sessions and multiplex them to look like a single interface to the routing processes. Underneath the VMI are virtual access interfaces that are associated with each of the PPP and PPPoE connections.

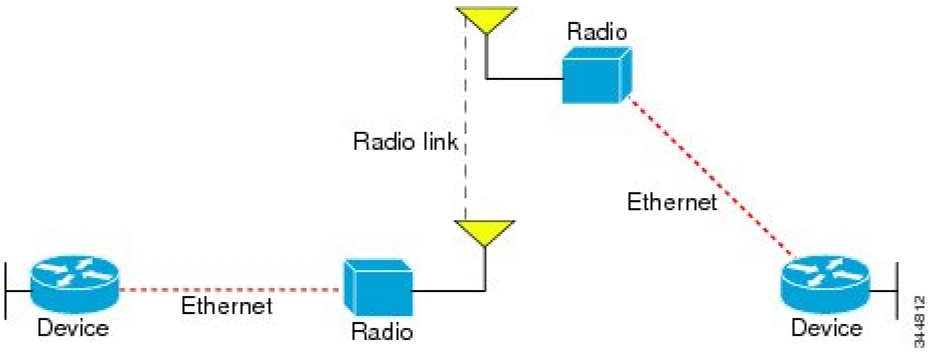
A PPPoE session is established between a device and a radio on behalf of every other device and radio neighbor located in the MANET. These Layer 2 sessions are the means by which radio network status gets reported to the Layer 3 processes in the device. The figure below shows the PPPoE session exchange between mobile devices and directional radios in a MANET network.

Figure 1: PPPoE Session Exchange Between Mobile Devices and Directional Radios



This capability requires that a Radio-Aware Routing (RAR)-compliant radio be connected to a device through Ethernet. The device always considers the Ethernet link to be up. If the radio side of the link goes down, the device waits until a routing update timeout occurs to declare the route down and then updates the routing table. The figure below shows a simple device-to-radio link topology.

Figure 2: Device-to-Radio Link



Neighbor Up and Down Signaling

Mobile Ad Hoc Networks (MANETs) are highly dynamic environments. Nodes might move into, or out of, radio range at a fast pace. Each time a node joins or leaves, the network topology must be logically reconstructed by the devices. Routing protocols normally use timer-driven hello messages or neighbor timeouts to track topology changes, but MANETs reliance on these mechanisms can result in unacceptably slow convergence.

The neighbor up/down signaling capability provides faster network convergence by using link-status signals generated by the radio. The radio notifies the device each time a link to another neighbor is established or terminated by the creation and termination of PPP over Ethernet (PPPoE) sessions. In the device, the routing protocols (Open Shortest Path First version 3 [OSPFv3] or Enhanced Interior Gateway Routing Protocol [EIGRP]) respond immediately to these signals by expediting formation of a new adjacency (for a new neighbor) or tearing down an existing adjacency (if a neighbor is lost). For example, if a vehicle drives behind a building and loses its connection, the device immediately senses the loss and establishes a new route to the vehicle through neighbors that are not blocked. This high-speed network convergence is essential for minimizing dropped voice calls and disruptions to video sessions.

When virtual multipoint interfaces (VMIs) with PPPoE are used and a partner node has left or a new one has joined, the radio informs the device immediately of the topology change. Upon receiving the signal, the device immediately declares the change and updates the routing tables. The signaling capability provides these advantages:

- Reduces routing delays and prevents applications from timing out
- Enables network-based applications and information to be delivered reliably and quickly over directional radio links
- Provides faster convergence and optimal route selection so that delay-sensitive traffic such as voice and video are not disrupted
- Reduces impact on radio equipment by minimizing the need for internal queueing and buffering
- Provides consistent quality of service for networks with multiple radios

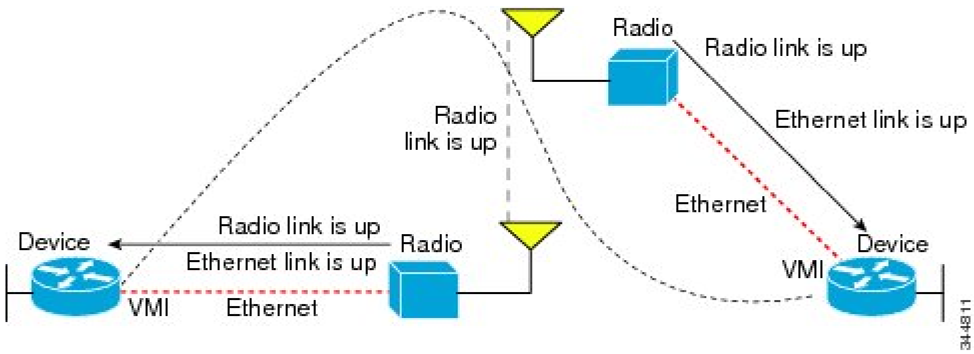
The messaging allows for flexible rerouting when necessary because of these factors:

- Fading of the radio links
- Congestion of the radio links

- Radio link power fade
- Utilization of the radio

The figure below shows the signaling sequence that occurs when radio links go up and down:

Figure 3: Up and Down Signaling Sequence



PPPoE Credit-based and Metric-based Scaling and Flow Control

Each radio initiates a PPP over Ethernet (PPPoE) session with its local device as soon as the radio establishes a link to another radio. Once the PPPoE sessions are active for each node, a PPP session is then established end-to-end (device-to-device). This process is duplicated each time a radio establishes a new link.

The carrying capacity of each radio link might vary due to location changes or environmental conditions, and many radio transmission systems have limited buffering capabilities. To minimize the need for packet queueing in the radio, PPPoE protocol extensions enable the device to control traffic buffering in congestion situations. Implementing flow-control on these device-to-radio sessions allows use of quality of service (QoS) features such as fair queueing.

The flow-control solution utilizes a credit-granting mechanism documented in RFC 5578. When the PPPoE session is established, the radio can request a flow-controlled session. If the device acknowledges the request, all subsequent traffic must be flow controlled. If a flow-control session is requested and cannot be supported by the device, the session is terminated. Typically, both the radio and the device initially grant credits during session discovery. Once a device exhausts its credits, it must stop sending until additional credits are granted. Credits can be added incrementally over the course of a session.

Metrics scaling is used with high-performance radios that require high-speed links. The radio can express the maximum and current data rates with different scaler values. Credit scaling allows a radio to change the default credit grant (or scaling factor) of 64 bytes to its default value. You can display the maximum and current data rates and the scalar value set by the radio in the show vmi neighbor detail command output.

QoS Provisioning on PPPoE Extension Session

The following example describes QoS provisioning on PPPoE extension session:

```
policy-map rar_policer
 class class-default
  police 10000 2000 1000 conform-action transmit  exceed-action drop  violate-action drop
policy-map rar_shaper
 class class-default
  shape average percent 1
```

```
interface Virtual-Template2
 ip address 92.92.2.1 255.255.255.0
 no peer default ip address
 no keepalive
 service-policy input rar_policer
end
```

Example: Configuring the RAR Feature in Bypass Mode

The following example is an end-to-end configuration of RAR in the bypass mode:

Note Before you begin the RAR configuration, you must first configure the **subscriber authorization enable** command to bring up the RAR session. Without enabling authorization, the Point-to-Point protocol does not recognize this as a RAR session and may not tag *manet_radio* in presentation of a PPPoE Active Discovery Initiate (PADI). By default, bypass mode does not appear in the configuration. It appears only if the mode is configured as bypass.

Configure a Service for RAR

```
policy-map type service rar-lab
 pppoe service manet_radio //note: Enter the pppoe service policy name as manet_radio
!
```

Configure Broadband

```
bba-group pppoe VMI2
 virtual-template 2
service profile rar-lab
!
interface GigabitEthernet0/0/0
 description Connected to Client1
  negotiation auto
  pppoe enable group VMI2
!
```

Configuration in Bypass Mode

- **IP Address Configured under Virtual-Template Explicitly**

```
interface Virtual-Template2
ip address 192.168.90.3 255.255.255.0
no ip redirects
peer default ip address pool PPPoEpool2
ipv6 enable
ospfv3 1 network manet
ospfv3 1 ipv4 area 0
ospfv3 1 ipv6 area 0
no keepalive
service-policy input rar_policer Or/And
service-policy output rar_shaper
```

- **VMI Unnumbered Configured under Virtual Template**

```
interface Virtual-Template2
ip unnumbered vmi2
no ip redirects
peer default ip address pool PPPoEpool2
ipv6 enable
ospfv3 1 network manet
ospfv3 1 ipv4 area 0
ospfv3 1 ipv6 area 0
no keepalive
service-policy input rar_policer Or/And
service-policy output rar_shaper
```

Configure the Virtual Multipoint Interface in Bypass Mode

```
interface vmi2 //configure the virtual multi interface
ip address 192.168.2.1 255.255.255.0
physical-interface GigabitEthernet0/0/0
mode bypass
```

Configure OSPF Routing

```
router ospfv3 1
 router-id 1.1.1.1
!
 address-family ipv4 unicast
  redistribute connected metric 1 metric-type 1
  log-adjacency-changes
 exit-address-family
 !
 address-family ipv6 unicast
  redistribute connected metric-type 1
  log-adjacency-changes
 exit-address-family
!
ip local pool PPPoEpool2 192.168.2.3 192.168.2.254
```

Verifying RAR Session Details

To retrieve RAR session details, use the following show commands:

```
Router#show pppoe session packets all
Total PPPoE sessions 2

session id: 9
local MAC address: 006b.f10e.a5e0, remote MAC address: 0050.56bc.424a
virtual access interface: Vi2.1, outgoing interface: Gi0/0/0
    1646 packets sent, 2439363 received
    176216 bytes sent, 117250290 received

PPPoE Flow Control Stats
 Local Credits: 65535   Peer Credits: 65535   Local Scaling Value 64 bytes
 Credit Grant Threshold: 28000    Max Credits per grant: 65535
 Credit Starved Packets: 0
 PADG xmit Seq Num: 32928     PADG Timer index: 0
 PADG last rcvd Seq Num: 17313
 PADG last nonzero Seq Num: 17306
```

```
 PADG last nonzero rcvd amount: 2
 PADG Timers: (ms)   [0]-1000    [1]-2000    [2]-3000    [3]-4000    [4]-5000
 PADG xmit: 33308  rcvd: 17313
 PADC xmit: 17313  rcvd: 19709
 In-band credit pkt xmit: 7 rcvd: 2434422
 Last credit packet snapshot
  PADG xmit: seq_num = 32928, fcn = 0, bcn = 65535
  PADC rcvd: seq_num = 32928, fcn = 65535, bcn = 65535
  PADG rcvd: seq_num = 17313, fcn = 0, bcn = 65535
  PADC xmit: seq_num = 17313, fcn = 65535, bcn = 65535
  In-band credit pkt xmit: fcn = 61, bcn = 65533
  In-band credit pkt rcvd: fcn = 0, bcn = 65534
    ==== PADQ Statistics ====
     PADQ xmit: 0  rcvd: 0


session id: 10
local MAC address: 006b.f10e.a5e1, remote MAC address: 0050.56bc.7dcb
virtual access interface: Vi2.2, outgoing interface: Gi0/0/1
    1389302 packets sent, 1852 received
    77869522 bytes sent, 142156 received

PPPoE Flow Control Stats
 Local Credits: 65535   Peer Credits: 65535   Local Scaling Value 64 bytes
 Credit Grant Threshold: 28000    Max Credits per grant: 65535
 Credit Starved Packets: 0
 PADG xmit Seq Num: 18787     PADG Timer index: 0
 PADG last rcvd Seq Num: 18784
 PADG last nonzero Seq Num: 18768
 PADG last nonzero rcvd amount: 2
 PADG Timers: (ms)   [0]-1000    [1]-2000    [2]-3000    [3]-4000    [4]-5000
 PADG xmit: 18787  rcvd: 18784
 PADC xmit: 18784  rcvd: 18787
 In-band credit pkt xmit: 1387764 rcvd: 956
 Last credit packet snapshot
  PADG xmit: seq_num = 18787, fcn = 0, bcn = 65535
  PADC rcvd: seq_num = 18787, fcn = 65535, bcn = 65535
  PADG rcvd: seq_num = 18784, fcn = 0, bcn = 65535
  PADC xmit: seq_num = 18784, fcn = 65535, bcn = 65535
  In-band credit pkt xmit: fcn = 0, bcn = 64222
  In-band credit pkt rcvd: fcn = 0, bcn = 65534
    ==== PADQ Statistics ====
     PADQ xmit: 0  rcvd: 1


Router#show pppoe session packets
Total PPPoE sessions 2

SID     Pkts-In         Pkts-Out        Bytes-In        Bytes-Out
9       2439391         1651            117252098       176714
10      1858            1389306         142580          77869914


Router#show vmi counters
Interface vmi2: - Last Clear Time =

Input Counts:
  Process Enqueue      =          0 (VMI)
  Fastswitch           =          0
  VMI Punt Drop:
       Queue Full      =          0

Output Counts:
  Transmit:
```

```
       VMI Process DQ  =       4280
       Fastswitch VA   =          0
       Fastswitch VMI  =          0
  Drops:
       Total           =          0
       QOS Error       =          0
       VMI State Error =          0
       Mcast NBR Error =          0
       Ucast NBR Error =          0
Interface vmi3: - Last Clear Time =

Input Counts:
  Process Enqueue      =          0 (VMI)
  Fastswitch           =          0
  VMI Punt Drop:
       Queue Full      =          0

Output Counts:
  Transmit:
       VMI Process DQ  =       2956
       Fastswitch VA   =          0
       Fastswitch VMI  =          0
  Drops:
       Total           =          0
       QOS Error       =          0
       VMI State Error =          0
       Mcast NBR Error =          0
       Ucast NBR Error =          0
Interface vmi4: - Last Clear Time =

Input Counts:
  Process Enqueue      =          0 (VMI)
  Fastswitch           =          0
  VMI Punt Drop:
       Queue Full      =          0

Output Counts:
  Transmit:
       VMI Process DQ  =          0
       Fastswitch VA   =          0
       Fastswitch VMI  =          0
  Drops:
       Total           =          0
       QOS Error       =          0
       VMI State Error =          0
       Mcast NBR Error =          0
       Ucast NBR Error =          0
Router#
```

```
Router#show vmi neighbor details
1 vmi2 Neighbors
1 vmi3 Neighbors
0 vmi4 Neighbors
2 Total Neighbors

vmi2   IPV6 Address=FE80::21E:E6FF:FE43:F500
       IPV6 Global Addr=::
       IPV4 Address=92.92.2.2, Uptime=05:15:01
       Output pkts=89, Input pkts=0
       No Session Metrics have been received for this neighbor.
       Transport PPPoE, Session ID=9
       INTERFACE STATS:
          VMI Interface=vmi2,
```

```
            Input qcount=0, drops=0, Output qcount=0, drops=0
         V-Access intf=Virtual-Access2.1,
            Input qcount=0, drops=0, Output qcount=0, drops=0
         Physical intf=GigabitEthernet0/0/0,
            Input qcount=0, drops=0, Output qcount=0, drops=0

PPPoE Flow Control Stats
 Local Credits: 65535   Peer Credits: 65535   Local Scaling Value 64 bytes
 Credit Grant Threshold: 28000    Max Credits per grant: 65535
 Credit Starved Packets: 0
 PADG xmit Seq Num: 33038     PADG Timer index: 0
 PADG last rcvd Seq Num: 17423
 PADG last nonzero Seq Num: 17420
 PADG last nonzero rcvd amount: 2
 PADG Timers: (ms)   [0]-1000    [1]-2000    [2]-3000    [3]-4000    [4]-5000
 PADG xmit: 33418  rcvd: 17423
 PADC xmit: 17423  rcvd: 19819
 In-band credit pkt xmit: 7 rcvd: 2434446
 Last credit packet snapshot
  PADG xmit: seq_num = 33038, fcn = 0, bcn = 65535
  PADC rcvd: seq_num = 33038, fcn = 65535, bcn = 65535
  PADG rcvd: seq_num = 17423, fcn = 0, bcn = 65535
  PADC xmit: seq_num = 17423, fcn = 65535, bcn = 65535
  In-band credit pkt xmit: fcn = 61, bcn = 65533
  In-band credit pkt rcvd: fcn = 0, bcn = 65534
    ==== PADQ Statistics ====
     PADQ xmit: 0  rcvd: 0


vmi3   IPV6 Address=FE80::21E:7AFF:FE68:6100
       IPV6 Global Addr=::
       IPV4 Address=91.91.91.4, Uptime=05:14:55
       Output pkts=6, Input pkts=0
       METRIC DATA: Total rcvd=1, Avg arrival rate (ms)=0
          CURRENT: MDR=128000 bps, CDR=128000 bps
                   Lat=0 ms, Res=100, RLQ=100, load=0
          MDR      Max=128000 bps, Min=128000 bps, Avg=128000 bps
          CDR      Max=128000 bps, Min=128000 bps, Avg=128000 bps
          Latency  Max=0, Min=0, Avg=0 (ms)
          Resource Max=100%, Min=100%, Avg=100%
          RLQ      Max=100, Min=100, Avg=100
          Load     Max=0%, Min=0%, Avg=0%
       Transport PPPoE, Session ID=10
       INTERFACE STATS:
          VMI Interface=vmi3,
             Input qcount=0, drops=0, Output qcount=0, drops=0
          V-Access intf=Virtual-Access2.2,
             Input qcount=0, drops=0, Output qcount=0, drops=0
          Physical intf=GigabitEthernet0/0/1,
             Input qcount=0, drops=0, Output qcount=0, drops=0

PPPoE Flow Control Stats
 Local Credits: 65535   Peer Credits: 65535   Local Scaling Value 64 bytes
 Credit Grant Threshold: 28000    Max Credits per grant: 65535
 Credit Starved Packets: 0
 PADG xmit Seq Num: 18896     PADG Timer index: 0
 PADG last rcvd Seq Num: 18894
 PADG last nonzero Seq Num: 18884
 PADG last nonzero rcvd amount: 2
 PADG Timers: (ms)   [0]-1000    [1]-2000    [2]-3000    [3]-4000    [4]-5000
 PADG xmit: 18896  rcvd: 18894
 PADC xmit: 18894  rcvd: 18896
 In-band credit pkt xmit: 1387764 rcvd: 961
 Last credit packet snapshot
```

```
  PADG xmit: seq_num = 18896, fcn = 0, bcn = 65535
  PADC rcvd: seq_num = 18896, fcn = 65535, bcn = 65535
  PADG rcvd: seq_num = 18894, fcn = 0, bcn = 65535
  PADC xmit: seq_num = 18894, fcn = 65535, bcn = 65535
  In-band credit pkt xmit: fcn = 0, bcn = 64222
  In-band credit pkt rcvd: fcn = 0, bcn = 65534
    ==== PADQ Statistics ====
     PADQ xmit: 0  rcvd: 1


Router#show vmi neighbor details vmi 2
              1 vmi2 Neighbors

vmi2   IPV6 Address=FE80::21E:E6FF:FE43:F500
       IPV6 Global Addr=::
       IPV4 Address=92.92.2.2, Uptime=05:16:03
       Output pkts=89, Input pkts=0
       No Session Metrics have been received for this neighbor.
       Transport PPPoE, Session ID=9
       INTERFACE STATS:
          VMI Interface=vmi2,
             Input qcount=0, drops=0, Output qcount=0, drops=0
          V-Access intf=Virtual-Access2.1,
             Input qcount=0, drops=0, Output qcount=0, drops=0
          Physical intf=GigabitEthernet0/0/0,
             Input qcount=0, drops=0, Output qcount=0, drops=0

PPPoE Flow Control Stats
 Local Credits: 65535   Peer Credits: 65535   Local Scaling Value 64 bytes
 Credit Grant Threshold: 28000    Max Credits per grant: 65535
 Credit Starved Packets: 0
 PADG xmit Seq Num: 33100     PADG Timer index: 0
 PADG last rcvd Seq Num: 17485
 PADG last nonzero Seq Num: 17449
 PADG last nonzero rcvd amount: 2
 PADG Timers: (ms)   [0]-1000    [1]-2000    [2]-3000    [3]-4000    [4]-5000
 PADG xmit: 33480  rcvd: 17485
 PADC xmit: 17485  rcvd: 19881
 In-band credit pkt xmit: 7 rcvd: 2434460
 Last credit packet snapshot
  PADG xmit: seq_num = 33100, fcn = 0, bcn = 65535
  PADC rcvd: seq_num = 33100, fcn = 65535, bcn = 65535
  PADG rcvd: seq_num = 17485, fcn = 0, bcn = 65535
  PADC xmit: seq_num = 17485, fcn = 65535, bcn = 65535
  In-band credit pkt xmit: fcn = 61, bcn = 65533
  In-band credit pkt rcvd: fcn = 0, bcn = 65534
    ==== PADQ Statistics ====
     PADQ xmit: 0  rcvd: 0


Router#show platform hardware qfp active feature ess session
Current number sessions: 2
Current number TC flow: 0
Feature Type: A=Accounting D=Policing(DRL) F=FFR M=DSCP Marking L=L4redirect P=Portbundle
T=TC

   Session    Type      Segment1      SegType1      Segment2      SegType2 Feature Other
-----------------------------------------------------------------------------------------
        21     PPP 0x0000001500001022    PPPOE 0x0000001500002023    LTERM -------
        24     PPP 0x0000001800003026    PPPOE 0x0000001800004027    LTERM -------


Router#show platform software subscriber pppoe_fctl evsi 21
PPPoE Flow Control Stats
```

```
 Local Credits: 65535   Peer Credits: 65535   Local Scaling Value 64 bytes
 Credit Grant Threshold: 28000    Max Credits per grant: 65535
 Credit Starved Packets: 0
 PADG xmit Seq Num: 33215     PADG Timer index: 0
 PADG last rcvd Seq Num: 17600
 PADG last nonzero Seq Num: 17554
 PADG last nonzero rcvd amount: 2
 PADG Timers: (ms)   [0]-1000    [1]-2000    [2]-3000    [3]-4000    [4]-5000
 PADG xmit: 33595  rcvd: 17600
 PADC xmit: 17600  rcvd: 19996
 In-band credit pkt xmit: 7 rcvd: 2434485
 Last credit packet snapshot
  PADG xmit: seq_num = 33215, fcn = 0, bcn = 65535
  PADC rcvd: seq_num = 33215, fcn = 65535, bcn = 65535
  PADG rcvd: seq_num = 17600, fcn = 0, bcn = 65535
  PADC xmit: seq_num = 17600, fcn = 65535, bcn = 65535
  In-band credit pkt xmit: fcn = 61, bcn = 65533
  In-band credit pkt rcvd: fcn = 0, bcn = 65534

BQS buffer statistics
 Current packets in BQS buffer: 0
 Total en-queue packets: 0 de-queue packets: 0
 Total dropped packets: 0

Internal flags: 0x0



Router#show platform hardware qfp active feature ess session id 21
Session ID: 21

  EVSI type: PPP
  SIP Segment ID: 0x1500001022
  SIP Segment type: PPPOE
  FSP Segment ID: 0x1500002023
  FSP Segment type: LTERM
  QFP if handle: 16
  QFP interface name: EVSI21
  SIP TX Seq num: 0
  SIP RX Seq num: 0
  FSP TX Seq num: 0
  FSP RX Seq num: 0
  Condition Debug: 0x00000000
    session



Router#show ospfv3 neighbor

          OSPFv3 1 address-family ipv4 (router-id 3.3.3.3)

Neighbor ID     Pri   State           Dead Time   Interface ID    Interface
1.1.1.1           0   FULL/  -        00:01:32    19              Virtual-Access2.1

          OSPFv3 1 address-family ipv6 (router-id 3.3.3.3)

Neighbor ID     Pri   State           Dead Time   Interface ID    Interface
1.1.1.1           0   FULL/  -        00:01:52    19              Virtual-Access2.1
Router#


Router#show ip route

Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
```

```
D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
E1 - OSPF external type 1, E2 - OSPF external type 2
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
a - application route
+ - replicated route, % - next hop override, p - overrides from PfR

Gateway of last resort is not set

      90.0.0.0/8 is variably subnetted, 3 subnets, 2 masks
C        90.90.90.0/24 is directly connected, Virtual-Access2.1
O        90.90.90.4/32 [110/1] via 90.90.90.4, 00:00:03, Virtual-Access2.1
L        90.90.90.5/32 is directly connected, Virtual-Access2.1
      92.0.0.0/32 is subnetted, 1 subnets
C        92.92.2.21 is directly connected, Virtual-Access2.1
```

Overview of DLEP

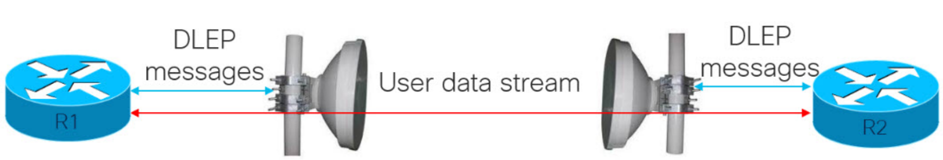
Cisco Dynamic Link Exchange Protocol (DLEP) is the latest protocol in the Radio Aware Routing (RAR) family. DLEP addresses the challenges faced when merging IP routing and radio frequency (RF) communications.

Cisco provides capabilities that enable:

- Optimal route selection based on feedback from radios
- Faster convergence when nodes join and leave the network
- Efficient integration of point-to-point, point-to-multipoint and broadcast multi-access radio topologies with multi-hop routing
- Flow-controlled communications between the radio and its partner router using rate-based Quality of Service (QoS) policies
- Dynamic shaping of fluctuating RF bandwidth in near real time to provide optimized use of actual RF bandwidth

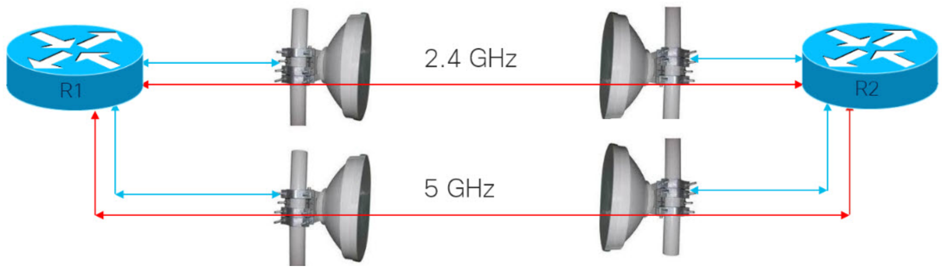
DLEP Topology and Packet Flow

The DLEP exchange between the router and radio allows the radio to tell the router about the link quality. This is somewhat analogous to the way the bar icon on your cell phone tells you about your Wi-Fi or LTE signal quality.



With DLEP, we can make use of routing distances with equal cost, where metrics are updated based in real time based on best path.

Without DLEP, there are two equal cost paths to any unadjusted routing protocol. With DLEP, routing metrics can be adjusted in real-time to favor the best path.



Note Atmospheric conditions and interference will ultimately favor one band versus the other.

DLEP Packet Flow

There are three different scenarios for packet flow:

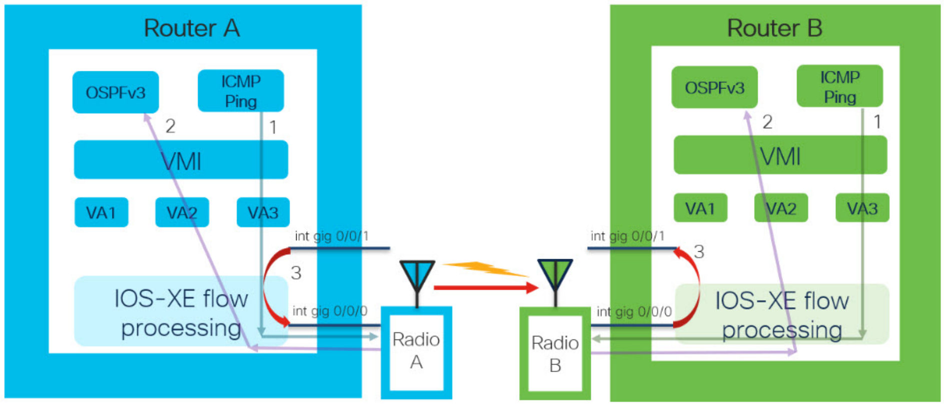
- Packet sent from IOS-XE to the DLEP neighbor (radio)
- Packet sent from DLEP neighbor (radio) to IOS-XE
- Non-DLEP traffic passing between the ESR-6300 Layer 3 (WAN) interfaces, for example, user traffic

Interfaces in IOS-XE Platform

- Virtual Multipoint Interface (VMI)
    - The VMI interface acts as an umbrella interface for all virtual access interfaces, which is used for routing protocols such as OSPFv3 and EIGRP.
    - Routing protocols, for example OSPFv3, see a single VMI interface instead of all VA interfaces. This helps reduce routing table size without impacting the integrity of network.
- Virtual Template (VT)
    - Virtual Template serves as the template for every Virtual Access interface.
- Virtual Access (VA) interface
    - One VA is created for each DLEP Neighbor (Radio) discovered.
- Underlaying physical Layer 3 WAN interface (Gi 0/0/0 and Gi 0/0/1), or even sub-interface (Gi 0/0/0.2 or Gi0/0/1.2

Packet Flow Diagram with Flow Types

The following diagram describes the packet flow:



Item	Description
1	Packet sent from IOS-XE to DLEP neighbor (to Radio): packet with DST MAC of neighbor MAC, neighbor IP sent out from DLEP Physical interface.
2	DLEP Packet (from radio) received thru DLEP Physical interface to IOS-XE: packet needs to be delivered to IOS routing protocol marked as from VMI interface.
3	End to End user data.

License Requirements

The Cisco Dynamic Link Exchange Protocol (DLEP) feature requires the Network Advantage license.

Configuring DLEP with OSPFv3

This section provides the following major sections for initiating, verifying, and managing all aspects of Dynamic Link Exchange Protocol (DLEP) on an interface. DLEP uses following interfaces that need to be configured:

- Physical interface
- VMI interface
- Virtual Templates

Important Before attaching a Virtual-Template to a physical interface, you need to configure the VMI and Virtual-Template. See the following example of the error you receive:

```
Router(config)#int gi0/0/0
Router(config-if)#ip dlep vtemplate 1
DLEP: ERROR. A valid VMI and Virtual Template MUST be present before configurating ip dlep
DLEP: ERROR. An Interface IP address MUST be specified for DLEP.
```

Configuring the Virtual Multipoint Interface

By default, virtual multipoint interfaces (VMIs) operate in aggregate mode, which means that all the virtual access interfaces created by DLEP sessions are aggregated logically under the configured VMI. Applications above Layer 2, such as the Enhanced Interior Gateway Routing Protocol (EIGRP) and Open Shortest Path First version 3 (OSPFv3), should be defined only on the VMI. Packets sent to the VMI are forwarded to the correct virtual access interface.

To configure the VMI, perform the following procedure:

Procedure

	Command or Action	Purpose

Step 1	**enable**
	Example:
	`Router> enable`
	`Router#`
		Enables privileged EXEC mode.
		• Enter your password if prompted.

Step 2	**configure terminal**
	Example:
	`Router# configure terminal`
	`Enter configuration commands, one per line.  End with CNTL/Z.`
	`Router(config)#`
		Enters global configuration mode.

Step 3	**interface vmi** *number*
	Example:
	`Router(config)# interface vmi 1`
	`Router(config-if)#`
		Creates a VMI and enters interface configuration mode.
		This example creates VMI1.

Step 4	**ip unnumbered** *interface* **Example:** `Router(config-if)#ip unnumbered gigabitEthernet {0/0/0 or 0/0/1 or 0/0/0.2}`	Tells the VMI interface to use the physical interface IP address.
Step 5	**physical-interface** *interface* **Example:** `Router(config-if)#physical-interface gigabitEthernet {0/0/0 or 0/0/1 or 0/0/0.2}`	Binding physical interface to VMI interface, for packet flow.
Step 6	**ipv6 enable** **Example:** `Router(config-if)# ipv6 enable`	Enable ipv6 support under VMI interface. OSPFv3 IPv4 needs to have ipv6 support enabled on the interface level.

	Command or Action	Purpose
Step 7	Configure routing protocols. **Example:** `Router(config-if)#`**`ospfv3 1 ipv4 area 0`**	Enable VMI interface to participate in OSPFv3 or EIGRP routing.
Step 8	**exit** **Example:** `Router(config-if)#` **`exit`** `Router(config)#`	Exits the current mode.
Step 9	router ospfv3 1 **Example:** `Router(config)#` **`router ospfv3 1`**	Global configuration for OSPFv3
Step 10	address-family ipv4 unicast **Example:** `Router(config-router)#` **`address-family ipv4 unicast`** `Router(config-router-af)#`	Adding address family for IPv4 unicast routing under global OSPFv3 configuration.

Configuring the Virtual Template

DLEP configuration requires virtual template to be defined. Perform this task to create the DLEP virtual template:

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router>` **`enable`** `Router#`	Enables privileged EXEC mode. • Enter your password if prompted.

Step 2	**configure terminal**
	Example:
	`Router#` **`configure terminal`**
	`Enter configuration commands, one per line.  End with CNTL/Z.`
	`Router(config)#`
		Enters global configuration mode.

Step 3	**interface Virtual-Template** *number* **Example:** `Router(config)#` **`interface Virtual-Template 1`** `Router(config-if)#`	Creates Virtual-Template interface and enters interface configuration mode. **Note** You need to use the same virtual-template interface for configuring DLEP on physical interface.

	Command or Action	Purpose
Step 4	**ip unnumbered** *interface* **Example:** `Router(config-if)#ip unnumbered gigabitEthernet {0/0/0 or 0/0/1 or 0/0/0.2`	Tells the Virtual-Template interface to use the physical interface IP address.

Step 5	**ipv6 enable**
	Example:
	`Router(config-if)# ipv6 enable`
	`Router(config)#`
		Enable ipv6 support under Virtual-Template interface. OSPFv3 IPv4 needs to have ipv6 support enabled on interface level.

Step 6	**exit**
	Example:
	`Router(config-if)# exit`
	`Router(config)#`
		Exits the current mode.

Configuring the Physical Interface

DLEP configuration is currently supported on the WAN interface of IOS-XE platforms. As described above, you need to configure both the VMI and Virtual-Template interface before configuring the physical interface. There are various ways that DLEP configuration can be attached to WAN interface, here are some of the examples:

1. DLEP template with well-known ip address [**Recommended**]
2. DLEP template with TCP/UDP port based between server (Router) and client (Radio)
3. DLEP template with dynamic port on server (Router)
4. DLEP template attach in discovery mode

For each of the four modes mentioned above, the user also has the option to enable Generalized TTL Security Mechanism (GTSM).

To configure DLEP on an interface, perform the following procedure:

Procedure

	Command or Action	Purpose

Step 1	**enable**
	Example:
	`Router> enable`
	`Router#`
		Enables privileged EXEC mode.
		• Enter your password if prompted.

Step 2	**configure terminal** **Example:**	Enters global configuration mode.

	Command or Action	Purpose

	`Router# configure terminal`
	`Enter configuration commands, one per line. End with CNTL/Z.`
	`Router(config)#`	

Step 3	**interface** *gi0/0/0 or gi0/0/1*
	Example:
	`Router(config)# interface gigabitEthernet 0/0/0`
	`Router(config-if)#`
		Enters interface configuration mode.

Step 4	**ipv6 enable** **Example:** `Router(config-if)#ipv6 enable`	Enable ipv6 support under interface level.
Step 5	Assigning IP address to physical interface **Example:** `Router(config-if)# ip address 10.0.0.1 255.255.255.0`	Assign physical IP address to the WAN interface.
Step 6	**ip dlep vtemplate** *port number* **Example:** `Router(config-if)#ip dlep vtemplate number 1`	Attaches DLEP Template to WAN interface, for discovery mode. Other configuration examples mentioned separately. **Note** Before attaching a DLEP template to a WAN interface, you need to configure a physical ip address, and create VMI and virtual templates.
Step 7	**no shutdown** **Example:** `Router(config-if)# no shutdown`	Bring up the interface.

Step 8	**exit**
	Example:
	`Router(config-if)# exit`
	`Router(config)#`
		Exits the current mode.

DLEP Configuration Modes

As mentioned in the previous section, DLEP virtual templates can be attached in different modes to the WAN or sub-interface of the router.

Note You must have VMI and Virtual-Templates already configured prior to continuing with any of the configuration modes in this section.

Configure DLEP Client/Server Based On Port Number

In this example, you are configuring the DLEP server, and client UDP and TCP ports.

Command or Action	Purpose
`Router(config)#`**`interface gi0/0/0`** `Router(config-if)#` **`ip address 10.0.0.1 255.255.255.0`** `Router(config-if)#` **`ipv6 enable`** `Router(config-if)#` **`ip dlep vtemplate 1 port 11113 tcp port 11114`** **`client ip 10.0.0.3 port 11115`** `Router(config-if)#` **`no shutdown`**	DLEP configuration where server (router) is listening to UDP port 11113 and TCP port 11114. Whereas client (radio) listening to TCP port 11115. UDP port of client is by default on 854.

Validate the above configuration using the **show dlep clients** command.

```
Router# show dlep clients
DLEP Clients for all interfaces:

DLEP Clients for Interface GigabitEthernet0/0/0
DLEP Server IP=10.0.0.1:11113 Sock=0

DLEP Client IP=10.0.0.3:11115 TCP Socket fd=1
Peer ID=1, Virtual template=1
 Description: DLEP-Radio1-Path-1
 Peer Timers (all values in milliseconds):
  Heartbeat=5000, Dead Interval=10000, Terminate ACK=20000
 Neighbor Timers (all values in seconds):
  Activity timeout=0, Neighbor Down ACK=10

 Supported Metrics:
  Link RLQ RX Metric : 100
  Link RLQ TX Metric : 100
  Link Resources Metric : 100
  Link MTU Metric : 100
  Link Latency Metric : 250 microseconds
  Link CDR RX Metric : 100000000 bps
  Link CDR TX Metric : 100000000 bps
  Link MDR RX Metric : 100000000 bps
  Link MDR TX Metric : 100000000 bps
```

Configure DLEP with Dynamic Port on Server (Router)

In this example, you are configuring the DLEP server, and client UDP and TCP ports.

Command or Action	Purpose
`Router(config)#`**`interface gi0/0/0`** `Router(config-if)#` **`ip address 10.0.0.1 255.255.255.0`** `Router(config-if)#` **`ipv6 enable`** `Router(config-if)#` **`ip dlep vtemplate 1 client ip 10.0.0.3 port 11115`** `Router(config-if)#` **`no shutdown`**	DLEP configuration where server (router) is listening to default UDP/TCP ports. Whereas client (radio) is listening to TCP port 11115. UDP port of client is by default on 854.

Validate the above configuration using the **show dlep clients** and **show dlep counters** commands.

```
Router# show dlep clients
DLEP Clients for all interfaces:
```

```
DLEP Clients for Interface GigabitEthernet0/0/0
DLEP Server IP=10.0.0.1:55555 Sock=0

DLEP Client IP=10.0.0.3:11115 TCP Socket fd=1
 Peer ID=1, Virtual template=1
 Description: DLEP-Radio1-Path-1
 Peer Timers (all values in milliseconds):
  Heartbeat=5000, Dead Interval=10000, Terminate ACK=20000
 Neighbor Timers (all values in seconds):
  Activity timeout=0, Neighbor Down ACK=10

 Supported Metrics:
  Link RLQ RX Metric : 100
  Link RLQ TX Metric : 100
  Link Resources Metric : 100
  Link MTU Metric : 100
  Link Latency Metric : 250 microseconds
  Link CDR RX Metric : 100000000 bps
  Link CDR TX Metric : 100000000 bps
  Link MDR RX Metric : 100000000 bps
  Link MDR TX Metric : 100000000 bps

Router# show dlep counters
DLEP Counters for GigabitEthernet0/0/0

Last Clear Time =

DLEP Version = RFC 8175
DLEP Server IP=10.0.0.1:55555
DLEPv5 TCP Port = 55556

Peer Counters:
 RX Peer Discovery     0      TX Peer Offer             0
 RX Peer Offer         0      TX Peer Discovery         0
 RX Peer Init          0      TX Peer Init Ack          0
 RX Peer Init Ack      1      TX Peer Init              1
 RX Heartbeat          58     TX Heartbeat              58
 RX Peer Terminate     0      TX Peer Terminate Ack     0
 RX Peer Terminate Ack 0      TX Peer Terminate         0

Neighbor Counters:
 RX Neighbor Up        0      TX Neighbor Up Ack        0
 RX Metric             0
 RX Neighbor Down      0      TX Neighbor Down Ack      0
 RX Neighbor Down Ack  0      TX Neighbor Down          0

Exception Counters:
 RX Invalid Message    0      RX Unknown Message        0
 Pre-Existing Neighbor 0      Neighbor Resource Error   0
 Neighbor Not Found    0      Neighbor Msg Peer Not Up  0

Timer Counters:
 Peer Heartbeat Timer         58
 Peer Terminate Ack Timer     0
 Neighbor Terminate Ack Timer 0
 Neighbor Activity Timer      0
 Radio Connect Timer          5

Single Timer Wheel "Manet Infra Wheel"
  Granularity      = 250 msec
  Wheel size       = 4096
  Spoke index      = 3592
  Tick count       = 3592
  Flags            = 0x00
```

```
  Active timers    = 1
  High water mark  = 2
  Started timers   = 164
  Restarted timers = 2
  Cancelled timers = 3
  Expired timers   = 158
  Long timers      = 0
  Long timer revs  = 0
  Timer suspends   = 0
```

Attach DLEP Template in Discovery Mode

When in discovery mode, the DLEP server will send out Peer Discovery signals, and wait for a Peer Offer signal from the radio.

Command or Action	Purpose
`Router(config)#`**`interface gi0/0/0`** `Router(config-if)#` **`ip address 10.0.0.1 255.255.255.0`** `Router(config-if)#` **`ipv6 enable`** `Router(config-if)#` **`ip dlep vtemplate 1`** `Router(config-if)#` **`no shutdown`**	DLEP configuration where server (router) is listening to default UDP/TCP ports. **Note** To receive the peer discovery messages, on client need to explicitly configure UDP port on client to 55555.

Validate the above configuration using the **show dlep clients** and **show dlep counters** commands.

```
Router# show dlep clients
DLEP Clients for all interfaces:

DLEP Clients for Interface GigabitEthernet0/0/0
DLEP Server IP=10.0.0.1:55555 Sock=0

DLEP Client IP=10.0.0.3:11115 TCP Socket fd=1
 Peer ID=1, Virtual template=1
 Description: DLEP-Radio1-Path-1
 Peer Timers (all values in milliseconds):
  Heartbeat=5000, Dead Interval=10000, Terminate ACK=20000
 Neighbor Timers (all values in seconds):
  Activity timeout=0, Neighbor Down ACK=10

 Supported Metrics:
  Link RLQ RX Metric : 100
  Link RLQ TX Metric : 100
  Link Resources Metric : 100
  Link MTU Metric : 100
  Link Latency Metric : 250 microseconds
  Link CDR RX Metric : 100000000 bps
  Link CDR TX Metric : 100000000 bps
  Link MDR RX Metric : 100000000 bps
  Link MDR TX Metric : 100000000 bps

Router# show dlep counters
DLEP Counters for GigabitEthernet0/0/0

Last Clear Time =

DLEP Version = RFC 8175
DLEP Server IP=10.0.0.1:55555
DLEPv5 TCP Port = 55556

Peer Counters:
 RX Peer Discovery     0      TX Peer Offer             0
```

```
 RX Peer Offer         3      TX Peer Discovery         194
 RX Peer Init          0      TX Peer Init Ack          0
 RX Peer Init Ack      3      TX Peer Init              3
 RX Heartbeat          710    TX Heartbeat              707
 RX Peer Terminate     0      TX Peer Terminate Ack     0
 RX Peer Terminate Ack 0      TX Peer Terminate         2

Neighbor Counters:
 RX Neighbor Up        0      TX Neighbor Up Ack        0
 RX Metric             0
 RX Neighbor Down      0      TX Neighbor Down Ack      0
 RX Neighbor Down Ack  0      TX Neighbor Down          0

Exception Counters:
 RX Invalid Message    0      RX Unknown Message        0
Pre-Existing Neighbor 0      Neighbor Resource Error   0
 Neighbor Not Found    0      Neighbor Msg Peer Not Up  0

Timer Counters:
 Peer Heartbeat Timer         709
 Peer Terminate Ack Timer     2
 Neighbor Terminate Ack Timer 0
 Neighbor Activity Timer      0
 Radio Connect Timer          3

Single Timer Wheel "Manet Infra Wheel"
  Granularity      = 250 msec
  Wheel size       = 4096
  Spoke index      = 8
  Tick count       = 24584
  Flags            = 0x00
  Active timers    = 1
  High water mark  = 2
  Started timers   = 1209
  Restarted timers = 4
  Cancelled timers = 14
  Expired timers   = 1190
  Long timers      = 0
  Long timer revs  = 0
  Timer suspends   = 0
```

Using a DLEP Template with a Well-Known IP Address

DLEP works based on RFC 8175, and it will use well-known ip address 224.0.0.117 on the server to communicate with radios. There are some additional pre-requisites that need to be enabled to make it work.

Procedure

	Command or Action	Purpose
Step 1	**ip multicast-routing distributed** **Example:** `ip multicast-routing distributed`	Enable multicast routing on Router
Step 2	**interface** *interface* **Example:**	Configure IPv4 address of the Server.

	Command or Action	Purpose

	`Router(config)# interface gi0/0/0`
	`Router(config-if)# ip address 10.1.2.3 255.255.255.0`
	`Router(config-if)# ipv6 enable`
	`Router(config-if)# no shutdown`	

Step 3	**ip pim sparse-dense-mode** **Example:** `Router(config-if)# ip pim sparse-dense-mode`	Enable sparse-dense mode.

Step 4	Configure forwarding
	Example:
	`Router(config-if)# ip mfib cef in`
	`Router(config-if)# ip mfib cef out`
	`Router(config-if)# ip mfib forwarding in`
	`Router(config-if)# ip mfib forwarding out`
		Enable the router to forward multicast traffic.

Step 5	**ip dlep vtemplate** <*Number*> **well-known ip** <*ip-address*> **Example:** `Router(config-if)# ip dlep vtemplate 1 well-known ip 224.0.0.117`	Enable DLEP vTemplate to listen to multi-cast traffic. **Note** Under the command **show running-configuration** the output will display as “ip dlep vtemplate 1” which means “well-known ip 224.0.0.117” is hidden

What to do next

Validate the above configuration using the **show dlep clients** command.

```
Router# show dlep clients

DLEP Clients for all interfaces:
DLEP Clients for Interface GigabitEthernet0/0/0
DLEP Server IP=10.1.2.3:55555 Sock=2

DLEP Client IP=10.1.2.4:854 TCP Socket fd=3
 Peer ID=1, Virtual template=1
 Description: OONF DLEP Radio
 Peer Timers (all values in milliseconds):
  Heartbeat=5000, Dead Interval=10000, Terminate ACK=20000
 Neighbor Timers (all values in seconds):
  Activity timeout=0, Neighbor Down ACK=10

 Supported Metrics:
  Link RLQ RX Metric : 100
  Link RLQ TX Metric : 100
  Link Resources Metric : 100
  Link Latency Metric : 1000 microseconds
  Link CDR RX Metric : 104857600 bps
  Link CDR TX Metric : 104857600 bps
  Link MDR RX Metric : 104857600 bps
  Link MDR TX Metric : 104857600 bps
```

DLEP Configuration with GTSM

Generalized TTL Security Mechanism (GTSM) can be used to provide an additional layer of security for the DLEP session.

The following table describes the different configuration modes:

DLEP Configuration Mode	Command to attach DLEP template under WAN or sub-interface
DLEP template with TCP/UDP port based between server and client.	`Router(config)# interface gi0/0/0` `Router(config-if)# ip dlep vtemplate 1 port 11113 tcp port 11114 gtsm client ip 10.0.0.3 port 11115`
DLEP configuration with dynamic port on server.	`Router(config)# interface gi0/0/0` `Router(config-if)# ip dlep vtemplate 1 gtsm client ip 10.0.0.3 port 11115`
DLEP template attach in discovery mode.	`Router(config)# interface gi0/0/0` `Router(config-if)# ip dlep vtemplate 1 gtsm`
DLEP template with well-known ip address.	`Router(config)# interface gi0/0/0` `Router(config-if)# ip dlep vtemplate 1 gtsm well-known ip 224.0.0.117`

Configuring DLEP with OSPFv3

This section describes configuring DLEP using OSPFv3.

Procedure

	Command or Action	Purpose

Step 1	**enable**
	Example:
	`Router> enable`
	`Router#`
		Enable privileged EXEC mode.

Step 2	**configure terminal**
	Example:
	`Router# configure terminal`
	`Router(config)#`
		Enter global configuration mode.

Step 3	**ipv6 unicast-routing**
	Example:
	`Router(config)# ipv6 unicast-routing`
	`Router(config-if)#`
		Enable ipv6 unicast routing. OSPFv3 IPv4 needs to have ipv6 support enabled on the interface level.

Step 4	**interface vmi** *number* **Example:**	Creates VMI interface and enters interface configuration mode.

	Command or Action	Purpose
	`Router#` **`interface vmi 1`** `Router(config-if)#`	
Step 5	**ip unnumbered** *interface* **Example:** `Router(config-if)#` **`ipv6 unnumbered gigibitEthernet 0/0/0 or 0/0/1 or 0/0/0.2`**	Specifies VMI interface to use physical interface IP address.
Step 6	**physical-interface** *interface* **Example:** `Router(config-if)#` **`physical-interface gigibitEthernet 0/0/0 or 0/0/1 or 0/0/0.2`**	Binding physical interface to VMI interface, for packet flow.
Step 7	**ipv6 enable** **Example:** `Router(config-if)#` **`ipv6 enable`**	Enable ipv6 support under VMI interface. OSPFv3 IPv4 needs to have ipv6 support enabled on the interface level.
Step 8	Configuring Routing Protocols **Example:** `Router(config-if)#` **`ospfv3 1 ipv4 area 0`**	Enable VMI interface to participate in OSPFv3 or EIGRP routing. This example is for OSPFv3. **Note** DLEP works only with OSPFv3 or EIGRP.
Step 9	**exit** **Example:** `Router(config-if)#` **`exit`** `Router(config)#`	Exits the current mode.
Step 10	**interface virtual-template** *number* **Example:** `Router(config)#` **`interface Virtual-Template 1`** `Router(config-if)#`	Creates Virtual-Template interface and enters interface configuration mode **Note** Need to use same virtual-template interface for attaching on physical-interface
Step 11	**ip unnumbered** *interface* **Example:** `Router(config-if)#` **`ip unnumbered gigibitEthernet 0/0/0 or 0/0/1 or 0/0/0.2`**	Specifies Virtual-Template interface to use physical interface IP address.
Step 12	**ipv6 enable** **Example:** `Router(config-if)#` **`ipv6 enable`**	Enable ipv6 support under Virtual-Template interface. OSPFv3 IPv4 needs to have ipv6 support enabled on interface level.
Step 13	**exit** **Example:** `Router(config-if)#` **`exit`** `Router(config)#`	Exits the current mode.
Step 14	**interface** *gi0/0/0 or gi0/0/1* **Example:**	Enter configuration mode for interface.

	Command or Action	Purpose
	`Router(config)# interface gi0/0/0` `Router(config-if)#`	
Step 15	**ipv6 enable** **Example:** `Router(config-if)# ipv6 enable`	Enable ipv6 support under interface level. OSPFv3 IPv4 needs to have ipv6 support enabled on the interface level.
Step 16	Assigning IP address to physical interface **Example:** `Router(config-if)# ip address 12.0.0.1`	Assign physical IP address to WAN interface.
Step 17	**ip dlep vtemplate** *number* **Example:** `Router(config-if)# ip dlep vtemplate 1 port 11117 tcp port 11115 client ip 12.0.0.2 port 859`	Attaching DLEP Template to WAN interface.
Step 18	**no shutdown** **Example:** `Router(config-if)# no shutdown`	Bring up the interface.

Step 19	**exit**
	Example:
	`Router(config-if)# exit`
	`Router(config)#`
		Exits the current mode.

Configuring DLEP with EIGRP

This section describes configuring DLEP using EIGRP.

Procedure

	Command or Action	Purpose

Step 1	**enable**
	Example:
	`Router> enable`
	`Router#`
		Enable privileged EXEC mode.

Step 2	**configure terminal**
	Example:
	`Router# configure terminal`
	`Router(config)#`
		Enter global configuration mode.

Step 3	**interface vmi** *number* **Example:**	Creates VMI interface and enters interface configuration mode.

	Command or Action	Purpose
	`Router(config)# interface vmi 1` `Router(config-if)#`	
Step 4	**ip unnumbered** *interface* **Example:** `Router(config-if)# ip unnumbered gigibitEthernet 0/0/0 or 0/0/1 or 0/0/0.2`	Tells VMI interface to use physical interface IP address.
Step 5	**physical-interface** *interface* **Example:** `Router(config-if)# physical-interface gigibitEthernet 0/0/0 or 0/0/1 or 0/0/0.2`	Binding physical interface to VMI interface, for packet flow.
Step 6	**ipv6 enable** **Example:** `Router(config-if)# ipv6 enable`	Enable ipv6 support under VMI interface. OSPFv3 IPv4 needs to have ipv6 support enabled on interface level.
Step 7	**no ip split-horizon eigrp** *number* **Example:** `Router(config-if)# no ip split-horizon eigrp 1`	Disable routing loops with EIGRP process.

Step 8	**exit**
	Example:
	`Router(config-if)# exit`
	`Router(config)#`
		Exits the current mode.

Step 9	**router eigrp** *<AS-NO>*
	Example:
	`Router(config)# router eigrp 1`
	`Router(config-router)#router-id 1.1.1.1`
	`Router(config-router)# network 10.0.0.0 0.0.0.255`
		Enable global configuration for EIGRP.
		Enable all the networks that can be part of EIGRP.

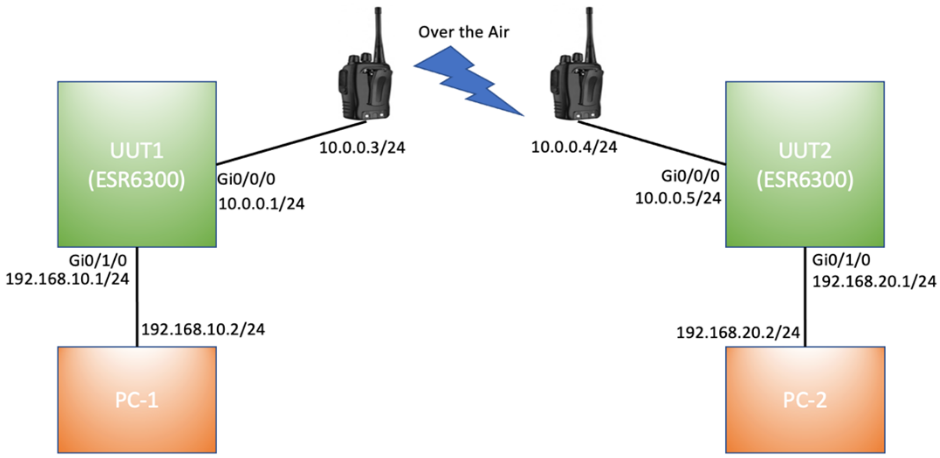
DLEP with Quality of Service (QoS)

Quality of Service (QoS) for DLEP needs to be configured on the Virtual-Template which is associated with the physical interface. QoS policy can be verified using the command **sh policy-map interface Virtual-Access**, as the actual data packets for DLEP will flow through the Virtual Access interfaces that will be created when DLEP neighbors come up.

Before proceeding, it is a good idea to familiarize yourself with content in the Quality of Service (QoS) Configuration Guide for IOS-XE.

DLEP QoS Example

The following figure shows an example topology for DLEP with QoS.



Based on above figure, the QoS policy is applied to egress of Virtual-Template attached to WAN interface Gi0/0/0.

UUT1 Running Configuration

```
UUT1# show running-config
Building configuration...

Current configuration : 7773 bytes
!
!
version 17.8
service timestamps debug datetime msec
service timestamps log datetime msec
service call-home
platform qfp utilization monitor load 80
platform punt-keepalive disable-kernel-core
!
hostname UUT1
!
boot-start-marker
boot system bootflash:/c6300-universalk9.SSA.bin
!
ipv6 unicast-routing
!
class-map match-any CMAP_VIDEO
 match dscp 33
 match dscp 35
 match dscp 37
 match dscp 39
 match dscp af41
class-map match-any CMAP_VOICE
 match dscp 41
 match dscp 43
 match dscp 45
 match dscp 47
 match dscp 49
class-map match-any CMAP_DATA
 match dscp 9
 match dscp 11
 match dscp 13
 match dscp 15
 match dscp af11
!
```

```
policy-map Queue_Map
 class CMAP_VOICE
  bandwidth percent 40
  set dscp af11
 class CMAP_VIDEO
  bandwidth percent 50
 class CMAP_DATA
  bandwidth percent 10
  set dscp af23
!
interface Loopback1
 ip address 1.1.1.1 255.255.255.255
 ipv6 enable
 ospfv3 1 ipv4 area 0
!
interface GigabitEthernet0/0/0
 ip address 10.0.0.1 255.255.255.0
 ip dlep vtemplate 1 port 11113 tcp port 11114 client ip 10.0.0.3 port 11115
 negotiation auto
 ipv6 address 1000::1/64
 ipv6 enable
!
interface GigabitEthernet0/0/1
 no ip address
 shutdown
 negotiation auto
!
interface GigabitEthernet0/1/0
 switchport access vlan 30
!
interface GigabitEthernet0/1/1
!
interface GigabitEthernet0/1/2
!
interface GigabitEthernet0/1/3
!
interface Virtual-Template1
 ip unnumbered GigabitEthernet0/0/0
 ipv6 enable
 service-policy output Queue_Map
!
interface Vlan1
 no ip address
!
interface Vlan30
 ip address 192.168.10.1 255.255.255.0
 ipv6 address 1010::1/64
 ipv6 enable
 ospfv3 1 ipv6 area 0
!
interface Async0/2/0
 no ip address
 encapsulation scada
!
interface vmi1
 ip unnumbered GigabitEthernet0/0/0
 ipv6 address FE80::7E31:EFF:FE85:1E78 link-local
 ipv6 enable
 ospfv3 1 ipv4 area 0
 physical-interface GigabitEthernet0/0/0
!
router ospfv3 1
 !
 router-id 1.1.1.1
```

```
 address-family ipv4 unicast
 exit-address-family
!
end
UUT1#
```

Validation for DLEP QoS

For the above example, where QoS policy is applied to Virtual-Template1, data packets are flowing through Virtual-Access2 interface which is created when DLEP neighbors came up.

Note The CLI **show policy-map interface Virtual-Template1** will not show the stats.

```
UUT1#show policy-map interface Virtual-Template 1
 Virtual-Template1

  Service-policy output: Queue_Map
```

Service policy content is displayed for cloned interfaces only such as virtual access and sessions.

See the output for Virtual-Access 2:

```
UUT1#show policy-map interface Virtual-Access 2
 Virtual-Access2
  Service-policy output: Queue_Map

    Class-map: CMAP_VOICE (match-any)
      0 packets, 0 bytes
      5 minute offered rate 0000 bps, drop rate 0000 bps
      Match:  dscp 41
      Match:  dscp 43
      Match:  dscp 45
      Match:  dscp 47
      Match:  dscp 49
      Queueing
      queue limit 208 packets
      (queue depth/total drops/no-buffer drops) 0/0/0
      (pkts output/bytes output) 0/0
      bandwidth 40% (400000 kbps)
      QoS Set
        dscp af11
          Marker statistics: Disabled

    Class-map: CMAP_VIDEO (match-any)
      0 packets, 0 bytes
      5 minute offered rate 0000 bps, drop rate 0000 bps
      Match:  dscp 33
      Match:  dscp 35
      Match:  dscp 37
      Match:  dscp 39
      Match:  dscp af41 (34)
      Queueing
      queue limit 208 packets
      (queue depth/total drops/no-buffer drops) 0/0/0
      (pkts output/bytes output) 0/0
      bandwidth 50% (500000 kbps)

    Class-map: CMAP_DATA (match-any)
      0 packets, 0 bytes
      5 minute offered rate 0000 bps, drop rate 0000 bps
      Match:  dscp 9
```

```
    Match:  dscp 11
    Match:  dscp 13
    Match:  dscp 15
    Match:  dscp af11 (10)
    Queueing
    queue limit 208 packets
    (queue depth/total drops/no-buffer drops) 0/0/0
    (pkts output/bytes output) 1024337/34827458
    bandwidth 10% (100000 kbps)
    QoS Set
      dscp af23
        Marker statistics: Disabled

  Class-map: class-default (match-any)
    0 packets, 0 bytes
    5 minute offered rate 0000 bps, drop rate 0000 bps
    Match: any

    queue limit 208 packets
    (queue depth/total drops/no-buffer drops) 0/0/0
    (pkts output/bytes output) 0/0
```

Edit the Virtual-Template

Before you begin

To edit the Virtual-Template, you need to remove the configuration for **ip dlep vtemplate** on the WAN interface.

Procedure

	Command or Action	Purpose

Step 1	**enable**
	Example:
	`Router> enable`
	`Router#`
		Enable privileged EXEC mode.

Step 2	**configure terminal**
	Example:
	`Router# configure terminal`
	`Router(config)#`
		Enter global configuration mode.

Step 3	**interface Virtual-Template** *number*
	Example:
	`Router(config)# interface Virtual-Template 1`
	`Router(config-if)#`
		Creates VMI interface and enters interface configuration mode.

Step 4	**Service-policy [input|output]** *<Policy-map>* **Example:** `Router(config-if)# service-policy output Queue_Map`	Apply policy-map to Egress/Ingress interface of Virtual-Template.

Configuring DLEP on a Sub-Interface

DLEP can also be configured on a sub-interface. The following is an example:

Procedure

	Command or Action	Purpose

Step 1	**enable**
	Example:
	`Router> enable`
	`Router#`
		Enable privileged EXEC mode.

Step 2	**configure terminal**
	Example:
	`Router# configure terminal`
	`Router(config)#`
		Enter global configuration mode.

Step 3	**interface** *interface*
	Example:
	`Router(config)# interface gi0/0/0`
	`Router(config-int)# no shut`
		WAN interface should be in active state.

Step 4	**interface** *sub-interface* **Example:** `Router(config-if)# interface gi0/0/0.2`	Creating sub-interface gi0/0/0.2
Step 5	**Encapsulation dot1q** *<VLAN>* **native** **Example:** `Router(config-subif)# encapsulation dot1q 2 native`	Adding encapsulation dot1q over VLAN 2, and making it native.
Step 6	**ip address** *<IP> <SUBNET>* **Example:** `Router(config-subif)# ip address 10.0.0.1 255.255.255.0`	Adding IPv4 address for sub-interface.
Step 7	**ipv6 enable** **Example:** `Router(config-subif)# ipv6 enable`	Adding IPv4 address for sub-interface. OSPFv3 IPv4 needs to have ipv6 support enabled on the interface level.

Step 8	**interface vmi** *number*
	Example:
	`Router(config-subif)# interface vmi 1`
	`Router(config-if)#`
		Creates VMI interface and enters interface configuration mode.

Step 9	**ip unnumbered** *interface* **Example:**	Specifies VMI interface to use physical interface IP address.

	Command or Action	Purpose
	`Router(config-if)# ip unnumbered gigabitEthernet 0/0/0.2`	
Step 10	**physical-interface** *interface* **Example:** `Router(config-if)# physical-interface gigabitEthernet 0/0/0.2`	Binding physical interface to VMI interface, for packet flow.
Step 11	**ipv6 enable** **Example:** `Router(config-if)# ipv6 enable`	Enable ipv6 support under VMI interface. OSPFv3 IPv4 needs to have ipv6 support enabled on interface level.
Step 12	**interface** *sub-interface* **Example:** `Router(config-if)# interface gi0/0/0.2`	Sub-interface configuration to add DLEP template.
Step 13	**ip dlep vtemplate** *<number>* **Example:** `Router(config-subif)# ip dlep vtemplate 1 gtsm client 10.0.0.2`	Attaching DLEP Template to sub-interface

Step 14	**exit**
	Example:
	`Router(config-if)# exit`
	`Router(config)#`
		Exits the current mode.

Step 15	**router eigrp** *<AS-NO>*
	Example:
	`Router(config)# router eigrp 1`
	`Router(config-router)#router-id 1.1.1.1`
	`Router(config-router)# network 10.0.0.0 0.0.0.255`
		Enable global configuration for EIGRP.

Example

```
Router# show running-config
Building configuration...
Current configuration : 7726 bytes
!
!
version 17.8
hostname Router
!
boot-start-marker
boot system bootflash:/c6300-universalk9.SSA.bin
boot-end-marker
!
ipv6 unicast-routing
subscriber templating
!
license udi pid ESR-6300-CON-K9 sn FOC234304H3
```

```
license boot level network-advantage
!
interface Loopback1
 ip address 1.1.1.1 255.255.255.255
 ipv6 enable
 ospfv3 1 ipv4 area 0
!
interface GigabitEthernet0/0/0
 no ip address
 negotiation auto
!
interface GigabitEthernet0/0/0.10
 encapsulation dot1Q 10
 ip address 10.0.0.1 255.255.255.0
 ip dlep vtemplate 1 port 11113 tcp port 11114 client ip 10.0.0.2 port 11115
 ipv6 enable
!
interface Virtual-Template1
 ip unnumbered GigabitEthernet0/0/0.10
!
interface vmi1
 ip unnumbered GigabitEthernet0/0/0.10
 ipv6 address FE80::7E31:EFF:FE85:1E78 link-local
 ipv6 enable
 ospfv3 1 network manet
 ospfv3 1 ipv4 area 0
 physical-interface GigabitEthernet0/0/0.10
!
router ospfv3 1
 !
 address-family ipv4 unicast
 exit-address-family
 !
 address-family ipv6 unicast
 exit-address-family
!
end

Router#
```

Removing the DLEP Configuration

Before editing or removing any configuration related to virtual template or VMI interface, you will need to remove the configuration for dlep vtemplate attached to WAN or sub-interface. If you try to edit the vmi interface, or the virtual-template, you will receive the following messages:

```
Router(config)#interface vmi1
vmi1 is associated with an instance of DLEP running on GigabitEthernet0/0/0.
Please remove DLEP configuration before making any changes to the VMI configuration.
Router(config)#interface Virtual-Template1
Virtual-Template1 is associated with an instance of DLEP running on GigabitEthernet0/0/0.
Please remove DLEP configuration before making any changes to the virtual-template.
```

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:**	Enable privileged EXEC mode.

	Command or Action	Purpose
	`Router> enable` `Router#`	

Step 2	**configure terminal**
	Example:
	`Router# configure terminal`
	`Router(config)#`
		Enter global configuration mode.

Step 3	**interface** *interface* **Example:** `Router(config)# interface gi0/0/0`	Interface mode.
Step 4	**no ip dlep vtemplate 1** **Example:** `Router(config-if)# no ip dlep vtemplate 1`	Detach DLEP configuration.
Step 5	**no int vmi** *<number>* **Example:** `Router(config-if)# no int vmi 1`	Removing vmi interface on Router.
Step 6	**no int Virtual-Template** *<number>* **Example:** `Router(config-if)# no int Virtual-Template 1`	Removing Virtual template on Router.

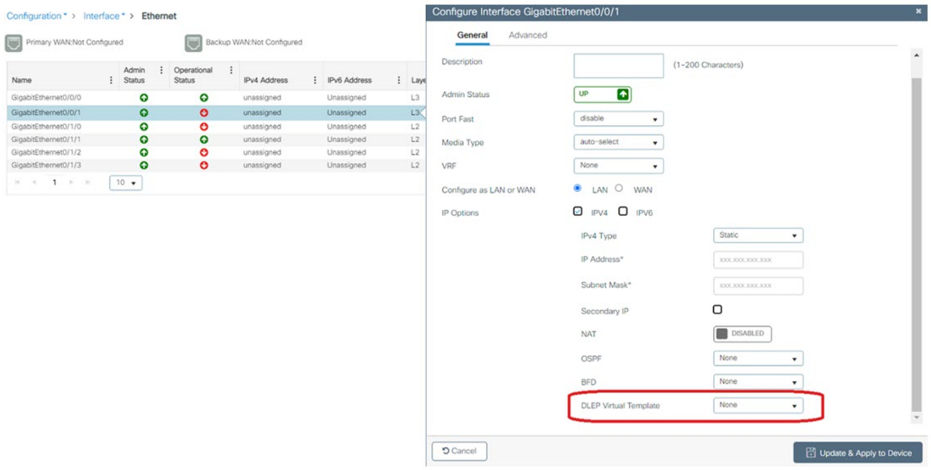
With the above configuration, DLEP will be removed from router. However, Virtual-Access interfaces that are created while bringing up DLEP neighbors, will still show up in the output of the **show ip interface brief** command until the system is rebooted.

Configuring DLEP using the Web User Interface (WebUI)

The following images illustrate how to configure DLEP using the WebUI.

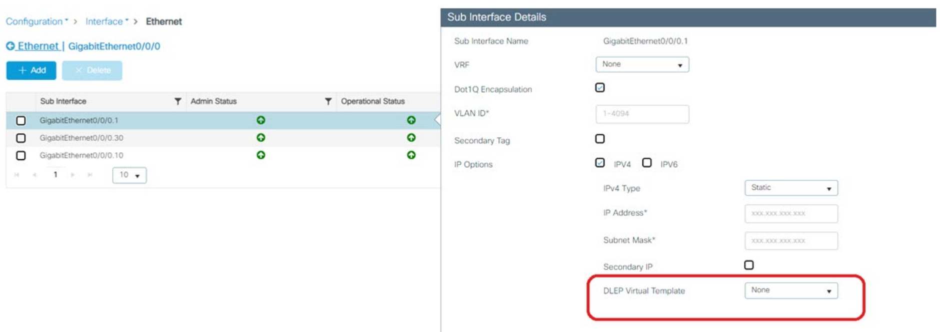
Configuring DLEP on Physical Interface

Navigate to **Configuration > Interface > Ethernet**. Select the interface to configure and then apply the DLEP Virtual Template. Click on **Update & Apply to Device**.



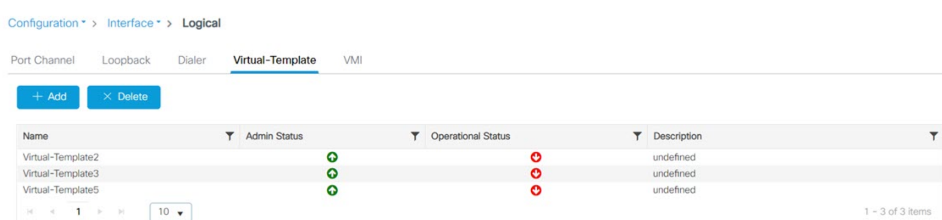
Configuring DLEP on the Sub-Interface

Navigate to **Configuration** > **Interface** > **Ethernet**. Select the sub-interface to configure and then apply the DLEP Virtual Template. Click on **Update & Apply to Device**.



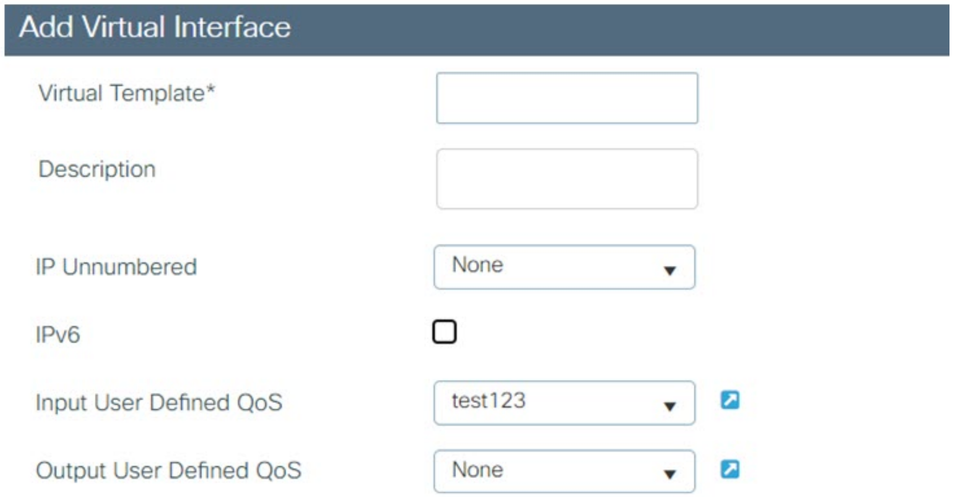
Configuring the Virtual-Template

Navigate to **Configuration** > **Interface** > **Logical**. Select the **Virtual-Template** tab. From here you can Add, Edit, or Delete interfaces.



Add/Edit the Virtual-Template

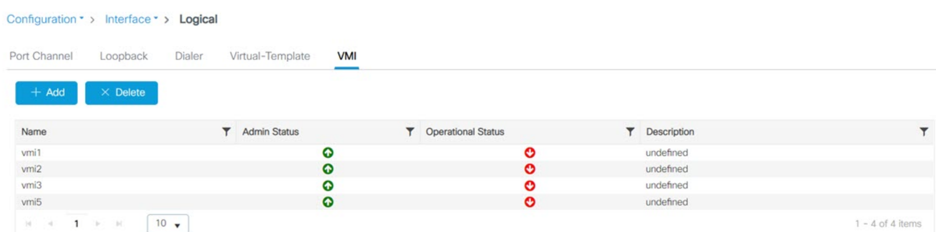
Select **Add**. The **Add Virtual Interface** window appears.



Click on **Apply to Device**.

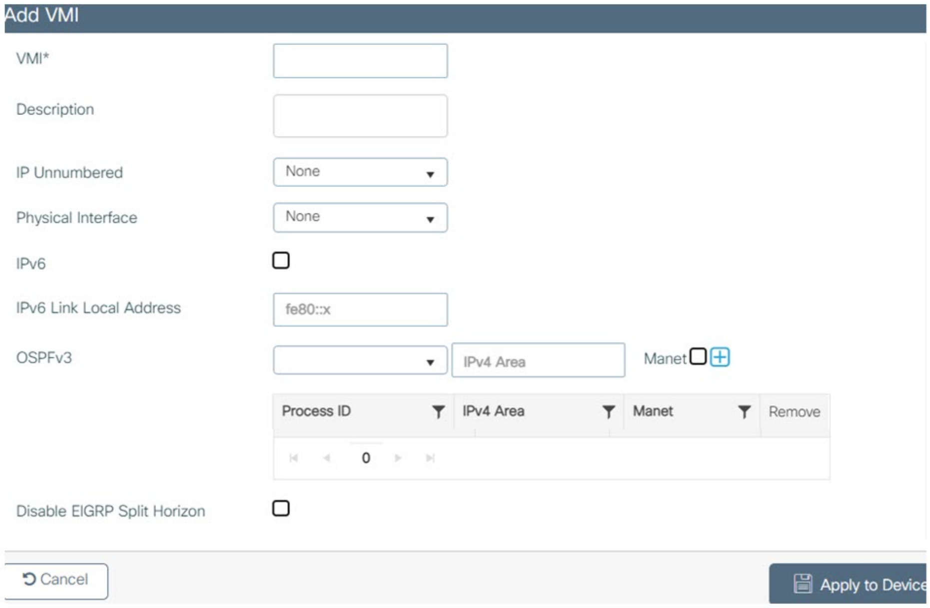
Configuring the VMI

Navigate to **Configuration** > **Interface** > **Logical**. Select the **VMI** tab. From here you can Add, Edit, or Delete interfaces.



Add/Edit the VMI

Select **Add**. The **Add VMI** window appears.



Click on **Apply to Device**.

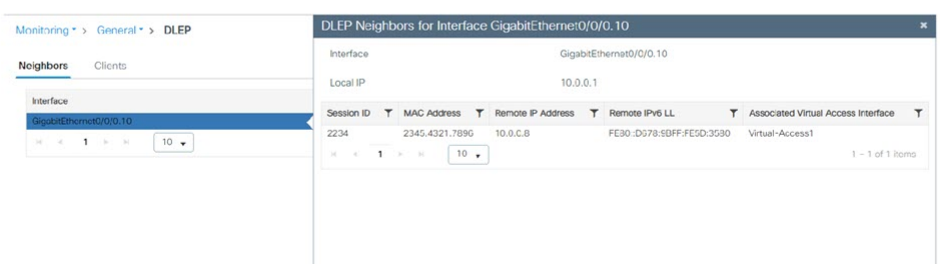
Monitoring DLEP

Navigate to **Monitoring** > **General** > **DLEP**. There are two tabs available for monitoring **`Neighbors`** or **Clients**. The Neighbors tab will display information equivalent to the CLI **show dlep neighbors**. The Clients tab will display information equivalent to the CLI **show dlep clients**.

DLEP Neighbors

Under the Neighbors tab, select the interface.

Open the interface to view the details.



DLEP Clients

The Clients tab works in the same manner as the Interface tab. Select the interface and open it to view the details.

DLEP Validation Commands

This section contains examples of how to verify the DLEP configuration on the router.

DLEP Configuration

Command	Information

Router# **show dlep config ?**
  GigabitEthernet GigabitEthernet IEEE 802.3z
 	
  | Output modifiers
  <cr> <cr>
	DLEP configuration is supported only on WAN or sub-interface.

```
Router# show dlep config g0/0/1
DLEP Configuration for GigabitEthernet0/0/1

DLEP Peer Description -
DLEP Version = RFC 8175
DLEP Server IP=10.0.0.1:11117
DLEPv27 TCP Port = 11118
Virtual template=2
Timers (all values are in seconds):
Missed heartbeat threshold=2, Peer Terminate ACK timeout=10
Dlepv27 Applicable configs(in seconds):
Heartbeat interval=5, Discovery interval =5, Session Ack timeout=10
Neighbor activity timeout=0, Neighbor Down ACK timeout=10
```

DLEP Clients

Command	Information

Router# **show dlep clients ?**
  GigabitEthernet GigabitEthernet IEEE 802.3z
 	
  | Output modifiers
  <cr> <cr>
	DLEP clients is supported only on WAN or sub-interface.

```
Router# show dlep clients
DLEP Clients for all interfaces:


DLEP Clients for Interface GigabitEthernet0/0/1
DLEP Server IP=10.0.0.1:11117 Sock=0 --> Local Router IP address
```

```
DLEP Client IP=10.0.0.2:859 TCP Socket fd=1 --> Directly connected Radio to the router
Peer ID=2, Virtual template=2
Description: DLEP_RadioSIM2
Peer Timers (all values in milliseconds):
  Heartbeat=5000, Dead Interval=10000, Terminate ACK=20000
Neighbor Timers (all values in seconds):
  Activity timeout=0, Neighbor Down ACK=10

Supported Metrics:
  Link RLQ RX Metric : 100
  Link RLQ TX Metric : 100
  Link Resources Metric : 100
  Link MTU Metric : 100
  Link Latency Metric : 250 microseconds
  Link CDR RX Metric : 100000000 bps
  Link CDR TX Metric : 100000000 bps
  Link MDR RX Metric : 100000000 bps
  Link MDR TX Metric : 100000000 bps
Router#
```

DLEP Neighbor

Command	Information
Router# **show dlep neighbor** ? GigabitEthernet GigabitEthernet IEEE 802.3z | Output modifiers <cr> <cr>	DLEP neighbors is supported only on WAN or sub-interface.

```
Router# show dlep neighbor
DLEP Neighbors for all interfaces:

DLEP Neighbors for Interface GigabitEthernet0/0/1
DLEP Server IP=10.0.0.1:11117 Sock=0   ---> Local Router IP address

SID=2151  MAC_Address=a453.0e94.f861
  Addresses:
  IPv4 : 16.0.0.1          ---> Mac-Address and IPv4 address of neighbor's end-point device
Supported Metrics:
  RLQ RX Metric : 100
  RLQ TX Metric : 100
  Resources Metric : 100
  MTU Metric : 1500
  Latency Metric : 250 microseconds
  CDR RX Metric : 100000000 bps
  CDR TX Metric : 100000000 bps
  MDR RX Metric : 100000000 bps
  MDR TX Metric : 100000000 bps
```

DLEP Counters

Command	Information
Router# **show dlep counters ?** GigabitEthernet GigabitEthernet IEEE 802.3z | Output modifiers <cr> <cr>	DLEP Counters is supported only on WAN or sub-interface, which will summarize port information, counters for peer, and neighbors.

```
UUT1# show dlep counters
DLEP Counters for GigabitEthernet0/0/1

Last Clear Time =

DLEP Version = RFC 8175
DLEP Server IP=10.0.0.1:11117
DLEPv5 TCP Port = 11118

Peer Counters:
RX Peer Discovery     0      TX Peer Offer             0
 RX Peer Offer         0      TX Peer Discovery         0
 RX Peer Init          0      TX Peer Init Ack          0
 RX Peer Init Ack      1      TX Peer Init              1
 RX Heartbeat          41     TX Heartbeat              41
 RX Peer Terminate     0      TX Peer Terminate Ack     0
 RX Peer Terminate Ack 0      TX Peer Terminate         0

Neighbor Counters:
RX Neighbor Up        1      TX Neighbor Up Ack        1
 RX Metric             0
 RX Neighbor Down      0      TX Neighbor Down Ack      0
 RX Neighbor Down Ack  0      TX Neighbor Down          1

Exception Counters:
RX Invalid Message    0      RX Unknown Message        0
 Pre-Existing Neighbor 0      Neighbor Resource Error   1
 Neighbor Not Found    0      Neighbor Msg Peer Not Up  0

Timer Counters:
Peer Heartbeat Timer         41
 Peer Terminate Ack Timer     0
 Neighbor Terminate Ack Timer 0
 Neighbor Activity Timer      0
 Radio Connect Timer          5

Single Timer Wheel "Manet Infra Wheel"
  Granularity      = 250 msec
  Wheel size       = 4096
  Spoke index      = 3730
  Tick count       = 3423890
  Flags            = 0x00
  Active timers    = 1
  High water mark  = 1
  Started timers   = 171177
  Restarted timers = 2
  Cancelled timers = 5
  Expired timers   = 171169
  Long timers      = 0
  Long timer revs  = 0
  Timer suspends   = 0
```

Optional Configurations for DLEP

There are set of optional commands that are available to configure for the **ip dlep** CLI under the WAN or sub-interface. Based on those commands, you can define the set of timeout intervals between peers, neighbors, and how long to send heart-beat intervals to radio's.

Command	Purpose
ip dlep set heartbeat-threshold ? `<2-8>  Threshold of missed heartbeat messages`	Set the heartbeat-threshold, between Server and Client.
ip dlep set nbr-activity-timeout ? `<0-240>  Neighbor Activity timer duration in seconds`	Set the neighbor activity timeout.
ip dlep set nbr-down-ack-timeout ? `<1-50>  Neighbor Down ACK timer duration in seconds`	Set the neighbor acknowledgment timeout.
ip dlep set peer-description ? `LINE  Peer Description Name`	Defines the description with Peer.
ip dlep set peer-heartbeat-interval ? `<1-60>  Peer Heartbeat Interval timer duration in seconds`	Set the heartbeat interval between Server and client.
ip dlep set peer-discovery-interval ? `<1-60>  Peer Discovery Interval timer duration in seconds`	Set the peer discovery interval timer.
ip dlep set peer-init-ack-timeout ? `<1-60>  Peer Init ACK timer duration in seconds`	Set the peer with init acknowledge messages from client.
ip dlep set peer-terminate-ack-timeout ? `<1-50>  Peer Terminate ACK timer duration in seconds`	Set the peer terminate acknowledge timer between client and server.

Clearing DLEP Clients and Neighbors

This section describes how the clear dlep client <interface> <peer id> command works, and possible ramifications.

When the **clear dlep client** command is issued on a router, the router sends a "Session Termination" message to the radio. The radio responds to this message by sending a "Session Termination Response" message. When the router receives the "Session Termination Response" message, it tears down the peer session.

When the radio is stopped gracefully, and after the **clear dlep client** command is issued on the router, the router will still send "Session Termination" message to the radio, but it won't be received by the radio, since it is already turned off. The router will automatically tear down the peer session after the timeout (heartbeat timer expiry) is reached.

The following shows an example:

Note First obtain the Peer ID from the output of the **show dlep client** CLI. Then, use that as the input to the **clear dlep client** CLI.

```
Router#show dlep client gi0/0/1

DLEP Clients for Interface GigabitEthernet0/0/1
```

```
DLEP Local IP=15.0.0.10:55555 Sock=0


DLEP Local Radio IP=15.0.0.2:856 TCP Socket fd=1
 Peer ID=20, Virtual template=2
 Description: DLEP_Radio_2042
 Peer Timers (all values in milliseconds):
  Heartbeat=60000, Dead Interval=120000, Terminate ACK=240000
 Neighbor Timers (all values in seconds):
  Activity timeout=0, Neighbor Down ACK=10

 Supported Metrics:
  Link RLQ RX Metric : 100
  Link RLQ TX Metric : 100
  Link Resources Metric : 100
  Link MTU Metric : 100
  Link Latency Metric : 250 microseconds
  Link CDR RX Metric : 100000000 bps
  Link CDR TX Metric : 100000000 bps
  Link MDR RX Metric : 100000000 bps
  Link MDR TX Metric : 100000000 bps
Router#

Router#clear dlep client gi0/0/1 20
DLEP: Clear Client (peer) peer_id=20 from 15.0.0.10
```

There is another clear dlep command that can be used. The clear dlep neighbor <interface> <session id> CLI will clear dlep neighbors. The session id can be obtained from show dlep neighbor command.

```
Router#clear dlep neighbor gi0/0/1 2215
DLEP: Clear neighbor sid=2215 from 195.0.0.2
```

Troubleshooting with show commands

The following series of figures illustrates what the output of various show commands mean in a sample installation.

Figure 4: Sample Installation

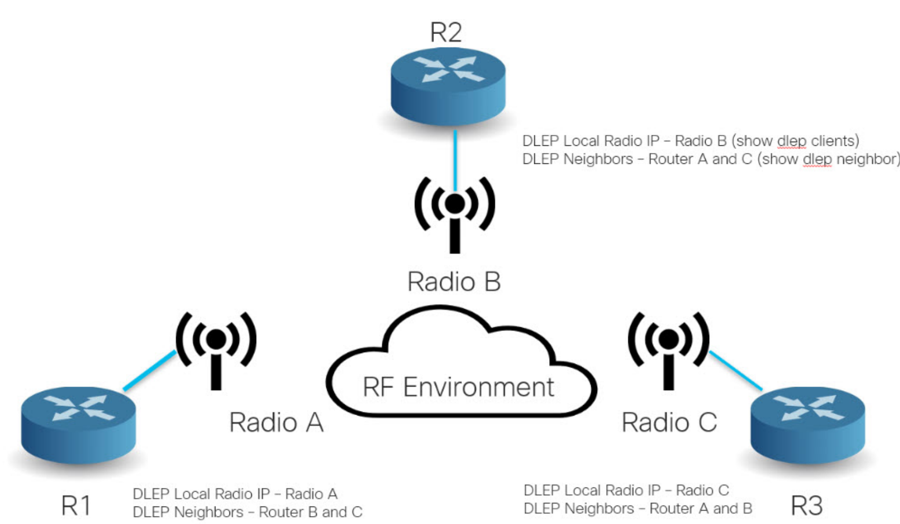
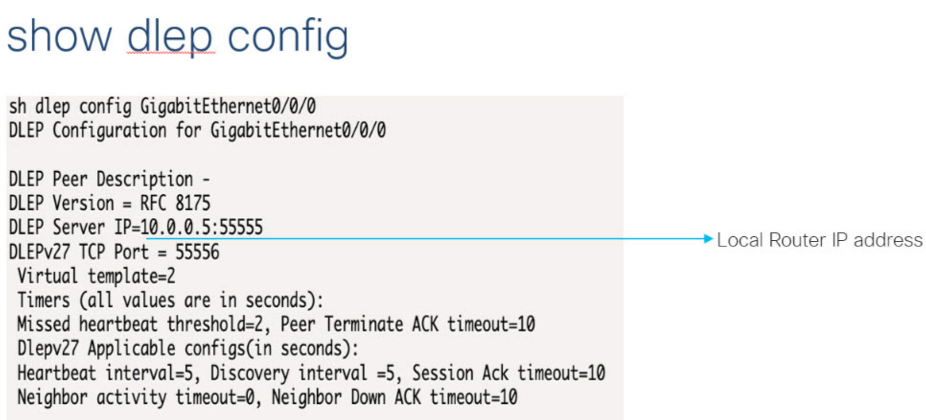


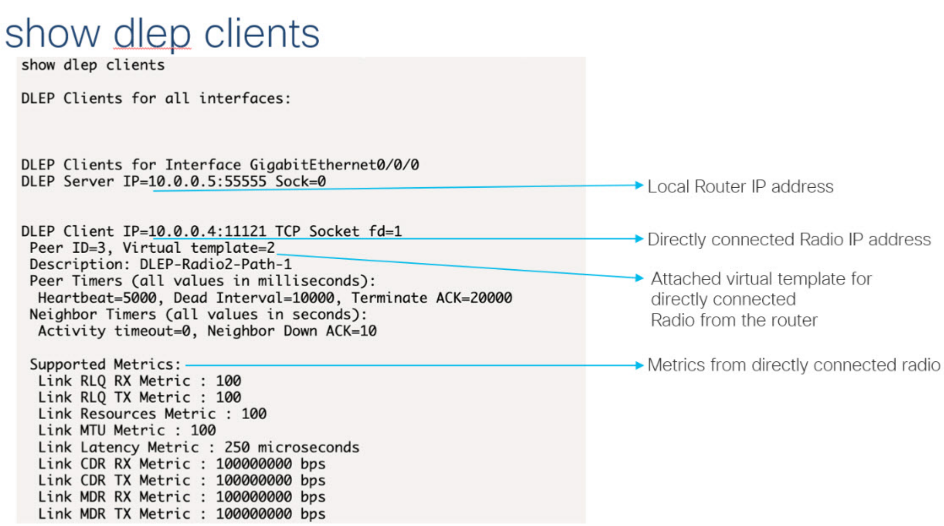
Figure 5: Show DLEP Configuration




```
sh dlep config GigabitEthernet0/0/0
DLEP Configuration for GigabitEthernet0/0/0

DLEP Peer Description -
DLEP Version = RFC 8175
DLEP Server IP=10.0.0.5:55555
DLEPv27 TCP Port = 55556
 Virtual template=2
 Timers (all values are in seconds):
 Missed heartbeat threshold=2, Peer Terminate ACK timeout=10
 Dlepv27 Applicable configs(in seconds):
 Heartbeat interval=5, Discovery interval =5, Session Ack timeout=10
 Neighbor activity timeout=0, Neighbor Down ACK timeout=10
```

Figure 6: Show DLEP Clients




```
show dlep clients

DLEP Clients for all interfaces:



DLEP Clients for Interface GigabitEthernet0/0/0
DLEP Server IP=10.0.0.5:55555 Sock=0


DLEP Client IP=10.0.0.4:11121 TCP Socket fd=1
 Peer ID=3, Virtual template=2
 Description: DLEP-Radio2-Path-1
 Peer Timers (all values in milliseconds):
  Heartbeat=5000, Dead Interval=10000, Terminate ACK=20000
 Neighbor Timers (all values in seconds):
  Activity timeout=0, Neighbor Down ACK=10

 Supported Metrics:
  Link RLQ RX Metric : 100
  Link RLQ TX Metric : 100
  Link Resources Metric : 100
  Link MTU Metric : 100
  Link Latency Metric : 250 microseconds
  Link CDR RX Metric : 100000000 bps
  Link CDR TX Metric : 100000000 bps
  Link MDR RX Metric : 100000000 bps
  Link MDR TX Metric : 100000000 bps
```

Figure 7: Show DLEP Neighbors

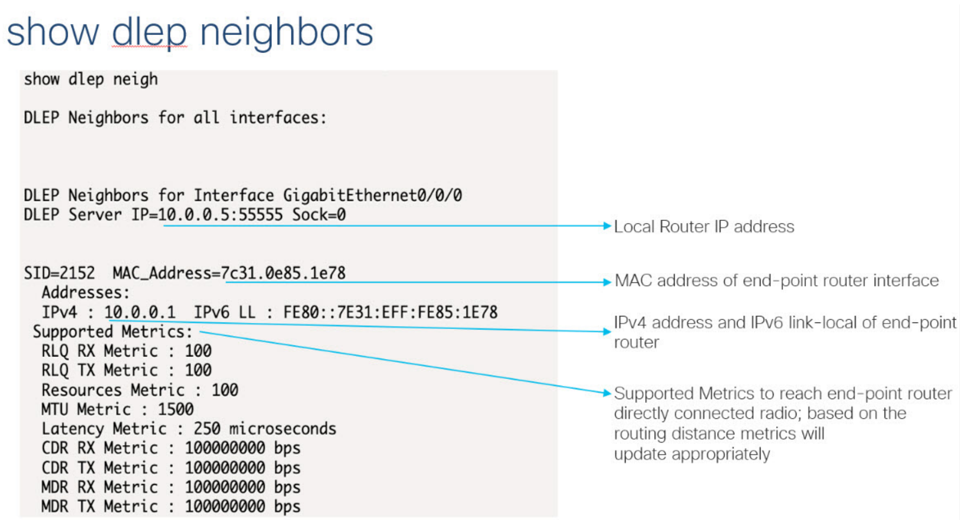
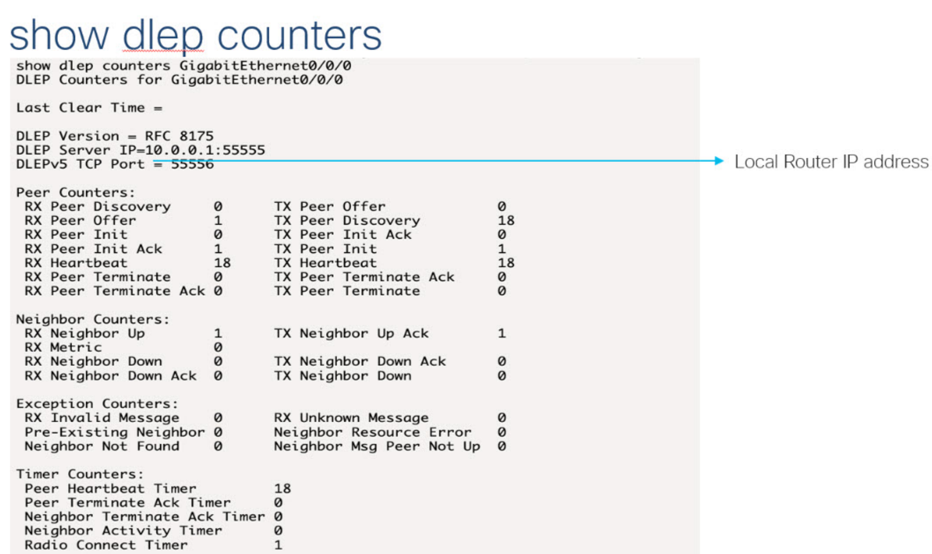


Figure 8: Show DLEP Counters



Troubleshooting with debug commands

This section shows two different troubleshooting scenarios.

Note We recommend using debug commands only when under the guidance of Cisco TAC.

Scenario 1 : DLEP client is not reachable

In this scenario, the router is not running in discovery mode, and the client/radio attributes have been explicitly configured.

Step 1: The output of **show dlep clients** indicates that there is no active client:

```
Router# show dlep clients

DLEP Clients for all interfaces:


DLEP Clients for Interface GigabitEthernet0/0/1
DLEP Server IP=14.0.0.3:11117 Sock=-1
```

Step 2: Check the DLEP configuration:

```
Router#show dlep config
DLEP Configuration for GigabitEthernet0/0/1

DLEP Peer Description -
DLEP Version = RFC 8175
DLEP Server IP=14.0.0.3:11117
DLEPv27 TCP Port = 11118
 Virtual template=2
 Timers (all values are in seconds):
 Missed heartbeat threshold=2, Peer Terminate ACK timeout=10
 Dlepv27 Applicable configs(in seconds):
 Heartbeat interval=60, Discovery interval =5, Session Ack timeout=10
 Neighbor activity timeout=0, Neighbor Down ACK timeout=10

Router#show run int g0/0/1
Building configuration...

Current configuration : 245 bytes
!
interface GigabitEthernet0/0/1
 ip address 14.0.0.3 255.255.255.0
 ip dlep set peer-heartbeat-interval 60
 ip dlep vtemplate 2 port 11117 tcp port 11118 client ip 14.0.0.6 port 859
 negotiation auto
 ipv6 address 1111::1/120
 ipv6 enable
end
```

Step 3: Verify that the configuration on the radio (client) matches the configuration on the router (server) and that the router can reach the radio.

```
Router#show ip arp
Protocol  Address          Age (min)  Hardware Addr   Type   Interface
Internet  10.199.184.2            9   0013.5f22.0b4a  ARPA   GigabitEthernet0/0/0
Internet  10.199.184.3            8   0018.7414.4e80  ARPA   GigabitEthernet0/0/0
Internet  10.199.184.19           -   a453.0e94.f638  ARPA   GigabitEthernet0/0/0
Internet  14.0.0.2                4   000c.297a.6b3d  ARPA   GigabitEthernet0/0/1
Internet  14.0.0.3                -   a453.0e94.f639  ARPA   GigabitEthernet0/0/1
Internet  14.0.0.6                0   Incomplete      ARPA

Router#ping 14.0.0.6
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 14.0.0.6, timeout is 2 seconds:
...
Success rate is 0 percent (0/3)
```

Step 4: We are unable to ping the client '14.0.0.6'. A quick check of the radio configuration revealed that the client IP address was actually 14.0.0.2.

```
Router#show run int g0/0/1
Building configuration...

Current configuration : 245 bytes
!
interface GigabitEthernet0/0/1
 ip address 14.0.0.3 255.255.255.0
 ip dlep set peer-heartbeat-interval 60
 ip dlep vtemplate 2 port 11117 tcp port 11118 client ip 14.0.0.6 port 859
 negotiation auto
 ipv6 address 1111::1/120
 ipv6 enable
end
```

Step 5: Correct the client IP address.

```
Router#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)#int g0/0/1
Router(config-if)#no ip dlep vtemplate 2 port 11117 tcp port 11118 client ip 14.0.0.6 port
 859
Router(config-if)# ip dlep set peer-heartbeat-interval 60
Router(config-if)#ip dlep vtemplate 2 port 11117 tcp port 11118 client ip 14.0.0.6 port 859
Router(config-if)#^Z
Router#
*Feb 18 19:43:48.951: %SYS-5-CONFIG_I: Configured from console by console
```

Step 6: Verify the fix.

```
Router#show dlep counters
DLEP Counters for GigabitEthernet0/0/1

Last Clear Time =

DLEP Version = RFC 8175
DLEP Server IP=14.0.0.3:11117
DLEPv5 TCP Port = 11118

Peer Counters:
 RX Peer Discovery     0      TX Peer Offer             0
 RX Peer Offer         0      TX Peer Discovery         0
 RX Peer Init          0      TX Peer Init Ack          0
 RX Peer Init Ack      1      TX Peer Init              1
 RX Heartbeat          0      TX Heartbeat              0
 RX Peer Terminate     0      TX Peer Terminate Ack     0
 RX Peer Terminate Ack 0      TX Peer Terminate         0

Neighbor Counters:
 RX Neighbor Up        0      TX Neighbor Up Ack        0
 RX Metric             0
 RX Neighbor Down      0      TX Neighbor Down Ack      0
 RX Neighbor Down Ack  0      TX Neighbor Down          0

Exception Counters:
 RX Invalid Message    0      RX Unknown Message        0
 Pre-Existing Neighbor 0      Neighbor Resource Error   0
 Neighbor Not Found    0      Neighbor Msg Peer Not Up  0

Timer Counters:
 Peer Heartbeat Timer         0
 Peer Terminate Ack Timer     0
 Neighbor Terminate Ack Timer 0
 Neighbor Activity Timer      0
 Radio Connect Timer          1
```

```
Single Timer Wheel "Manet Infra Wheel"
  Granularity      = 250 msec
  Wheel size       = 4096
  Spoke index      = 1710
  Tick count       = 9902
  Flags            = 0x00
  Active timers    = 1
  High water mark  = 1
  Started timers   = 95
  Restarted timers = 4
  Cancelled timers = 4
  Expired timers   = 86
  Long timers      = 0
  Long timer revs  = 0
  Timer suspends   = 0

Router#
Router#show dlep clients

DLEP Clients for all interfaces:

DLEP Clients for Interface GigabitEthernet0/0/1
DLEP Server IP=14.0.0.3:11117 Sock=0


DLEP Client IP=14.0.0.2:859 TCP Socket fd=1
 Peer ID=3, Virtual template=2
 Description: DLEP_RadioSIM2
 Peer Timers (all values in milliseconds):
  Heartbeat=60000, Dead Interval=120000, Terminate ACK=240000
 Neighbor Timers (all values in seconds):
  Activity timeout=0, Neighbor Down ACK=10

 Supported Metrics:
  Link RLQ RX Metric : 100
  Link RLQ TX Metric : 100
  Link Resources Metric : 100
  Link MTU Metric : 100
  Link Latency Metric : 250 microseconds
  Link CDR RX Metric : 100000000 bps
  Link CDR TX Metric : 100000000 bps
  Link MDR RX Metric : 100000000 bps
  Link MDR TX Metric : 100000000 bps
```

Scenario 2: DLEP session keeps timing out

In this scenario, the router is running in discovery mode.

Step 1: The DLEP session keeps flapping as indicated by the output of **show dlep client** sometimes shows an active client and sometimes it does not. Also, the VMI and virtual-access interfaces keep going up and down.

```
Router#show dlep clients

DLEP Clients for all interfaces:



DLEP Clients for Interface GigabitEthernet0/0/1
DLEP Server IP=14.0.0.3:55555 Sock=0


DLEP Client IP=14.0.0.2:859 TCP Socket fd=1
 Peer ID=13, Virtual template=2
```

```
 Description: DLEP_RadioSIM2
 Peer Timers (all values in milliseconds):
  Heartbeat=5000, Dead Interval=10000, Terminate ACK=20000
 Neighbor Timers (all values in seconds):
  Activity timeout=0, Neighbor Down ACK=10

 Supported Metrics:
  Link RLQ RX Metric : 100
  Link RLQ TX Metric : 100
  Link Resources Metric : 100
  Link MTU Metric : 100
  Link Latency Metric : 250 microseconds
  Link CDR RX Metric : 100000000 bps
  Link CDR TX Metric : 100000000 bps
  Link MDR RX Metric : 100000000 bps
  Link MDR TX Metric : 100000000 bps
Router#

*Feb 18 20:01:32.577: %SYS-5-CONFIG_P: Configured programmatically by process Manet Infra
Background from console as console
*Feb 18 20:01:32.580: %LINEPROTO-5-UPDOWN: Line protocol on Interface Virtual-Access3,
changed state to up
*Feb 18 20:01:32.584: %LINK-3-UPDOWN: Interface Virtual-Access3, changed state to up
*Feb 18 20:01:32.625: %LINEPROTO-5-UPDOWN: Line protocol on Interface vmi2, changed state
to up
Router#
Router#
*Feb 18 20:01:44.864: %LINEPROTO-5-UPDOWN: Line protocol on Interface vmi2, changed state
to down
*Feb 18 20:01:44.873: %LINEPROTO-5-UPDOWN: Line protocol on Interface Virtual-Access3,
changed state to down
*Feb 18 20:01:44.878: %LINK-3-UPDOWN: Interface Virtual-Access3, changed state to down
*Feb 18 20:01:44.889: %SYS-5-CONFIG_P: Configured programmatically by process VTEMPLATE
Background Mgr from console as console
```

Step 2: Turn on the following debug commands to troubleshoot:

```
debug dlep server
debug dlep timer detail
debug dlep client error
debug dlep client infra
debug dlep client packet detail
debug dlep client state
```

Step 3: The debug logs indicate that the router/server sent a peer discovery signal and received a peer offer in return.

```
*Feb 18 20:14:59.553: dlepv27_encoder_signal_packet_start DLEP_SIGNAL_PEER_DISCOVERY(1)
*Feb 18 20:14:59.553: dlepv27_encoder_signal_packet_end tlv block size=0 packet length=8
*Feb 18 20:15:04.609: dlepv27_encoder_signal_packet_start DLEP_SIGNAL_PEER_DISCOVERY(1)
*Feb 18 20:15:04.609: dlepv27_encoder_signal_packet_end tlv block size=0 packet length=8
*Feb 18 20:15:04.611: dlepv27_decoder_signal_packet DLEP_SIGNAL_PEER_OFFER(2) data length
30
*Feb 18 20:15:04.611: dlepv27_decoder_peer_type_tlv DLEP_TLV_PEER_TYPE   flag - 0
dlepv27_decoder_parse_tlv_block last tlv 4; current block_len 11; next tlv 2
IPv4 Addr 14.0.0.2dlepv27_decoder_ipv4_conn_point_tlv DLEP_TLV_IPv4_CONN_POINT
dlepv27_decoder_parse_tlv_block last tlv 2; current block_len 0;
*Feb 18 20:15:04.611:
*Feb 18 20:15:04.611: dlepv27_decoder_packet rc(RC_DLEP_OK-0) state 0 signal 1 packet_len
38
*Feb 18 20:15:09.648: %DLEP_MSG-4-CONNECT_ERROR: TCP connect to Radio 14.0.0.2 failed via
Gi0/0/1. Error code: Resource temporarily unavailable
```

Step 4: Observe that the router/server then sent a session initialization message, and received an acknowledgement in return. The acknowledgement also carries the attributes of the radio/client. An examination of those attributes reveals that the heartbeat interval on the radio is set to 60 seconds.

```
*Feb 18 20:15:09.648: dlepv27_encoder_msg_packet_start DLEP_MSG_SESSION_INITIALIZATION(1)
*Feb 18 20:15:09.648: dlepv27_encoder_msg_packet_end tlv block size=13 packet length=17
*Feb 18 20:15:09.649:   Adding Peer for address 14.0.0.2(859), peer_id=22
*Feb 18 20:15:09.649: MANET_Infra: insert s=FFFF771137A8, type=2 (client insert)
*Feb 18 20:15:09.650: MANET Infra: Insert=FFFF745209B0 successful (client insert)
*Feb 18 20:15:09.650: MANET_Infra: insert s=FFFF771137A8, type=1 (client insert)
*Feb 18 20:15:09.650: MANET Infra: Insert=FFFF64C3CEE8 successful (client insert)
*Feb 18 20:15:09.650:  -0 Allocated peer context at 0xFFFF771137A8
*Feb 18 20:15:09.650: dlepv27_decoder_msg_packet DLEP_MSG_SESSION_INITIALIZATION_ACK(2)
data length 132
dlepv27_decoder_status_tlv DLEP_TLV_STATUS  status_code=0 desc ()
dlepv27_decoder_parse_tlv_block last tlv 1; current block_len 127; next tlv 4

*Feb 18 20:15:09.650: dlepv27_decoder_peer_type_tlv DLEP_TLV_PEER_TYPE   flag - 0
dlepv27_decoder_parse_tlv_block last tlv 4; current block_len 108; next tlv 5
dlepv27_decoder_heartbeat_interval_tlv DLEP_TLV_HEARTBEAT_INTERVAL  heartbeat=60000
dlepv27_decoder_parse_tlv_block last tlv 5; current block_len 100; next tlv 12

*Feb 18 20:15:09.650: dlepv27_decoder_latency_data_rate_value DLEP_TLV_LINK_MDR_METRIC_RX
 value=100000000
dlepv27_decoder_parse_tlv_block last tlv 12; current block_len 88; next tlv 13

*Feb 18 20:15:09.650: dlepv27_decoder_latency_data_rate_value DLEP_TLV_LINK_MDR_METRIC_TX
 value=100000000
dlepv27_decoder_parse_tlv_block last tlv 13; current block_len 76; next tlv 14

*Feb 18 20:15:09.650: dlepv27_decoder_latency_data_rate_value DLEP_TLV_LINK_CDR_METRIC_RX
 value=100000000
dlepv27_decoder_parse_tlv_block last tlv 14; current block_len 64; next tlv 15

*Feb 18 20:15:09.650: dlepv27_decoder_latency_data_rate_value DLEP_TLV_LINK_CDR_METRIC_TX
 value=100000000
dlepv27_decoder_parse_tlv_block last tlv 15; current block_len 52; next tlv 16

*Feb 18 20:15:09.650: dlepv27_decoder_latency_data_rate_value DLEP_TLV_LINK_LATENCY_METRIC
  value=250
dlepv27_decoder_parse_tlv_block last tlv 16; current block_len 40; next tlv 18
dlepv27_decoder_rlq_resource_value DLEP_TLV_LINK_RLQ_METRIC_RX  value=100
dlepv27_decoder_parse_tlv_block last tlv 18; current block_len 35; next tlv 19
dlepv27_decoder_rlq_resource_value DLEP_TLV_LINK_RLQ_METRIC_TX  value=100
dlepv27_decoder_parse_tlv_block last tlv 19; current block_len 30; next tlv 17
dlepv27_decoder_rlq_resource_value DLEP_TLV_LINK_RESOURCES  value=100
dlepv27_decoder_parse_tlv_block last tlv 17; current block_len 25; next tlv 20
dlepv27_decoder_mtu_tlv DLEP_TLV_LINK_MTU  mtu=100
dlepv27_decoder_parse_tlv_block last tlv 20; current block_len 19; next tlv 8
IPv4 Addr 14.0.0.2dlepv27_decoder_ipv4_address_tlv DLEP_TLV_IPV4_ADDRESS  operation=1
dlepv27_decoder_parse_tlv_block last tlv 8; current block_len 10; next tlv 10
IPv4 Subnet Addr 255.255.255.0dlepv27_decoder_ipv4_address_subnet_tlv
DLEP_TLV_IPV4_ATTACHED_SUBNET  operation=1 mask=24
dlepv27_decoder_parse_tlv_block last tlv 10; current block_len 0;
*Feb 18 20:15:09.651:
*Feb 18 20:15:09.651: dlepv27_decoder_packet rc(RC_DLEP_OK-0) state 1 signal 0 packet_len
136
Router#
```

Step 5: The router appears to be sending heartbeats 5 seconds apart:

```
*Feb 18 20:15:14.569: dlepv27_decoder_msg_packet DLEP_MSG_PEER_HEARTBEAT(16) data length 0
```

```
*Feb 18 20:15:14.569:  -curr_state Dlep In-Session State normalized_event=Dlep Peer Heartbeat
 Event  p2peer=0xFFFF771137A8  peer_id=22  p2neighbor=0x0
*Feb 18 20:15:14.569: dlepv27_decoder_packet rc(RC_DLEP_OK-0) state 2 signal 0 packet_len
4
Router#
*Feb 18 20:15:19.569: dlepv27_decoder_msg_packet DLEP_MSG_PEER_HEARTBEAT(16) data length 0


*Feb 18 20:15:19.569:  -curr_state Dlep In-Session State normalized_event=Dlep Peer Heartbeat
 Event  p2peer=0xFFFF771137A8  peer_id=22  p2neighbor=0x0
*Feb 18 20:15:19.569: dlepv27_decoder_packet rc(RC_DLEP_OK-0) state 2 signal 0 packet_len
4
Router#
```

Step6: The router is terminating the session, and receiving an acknowledgement of the same:

```
*Feb 18 20:15:24.569: dlepv27_decoder_msg_packet DLEP_MSG_SESSION_TERM(5) data length 5
dlepv27_decoder_status_tlv DLEP_TLV_STATUS  status_code=0 desc ()
dlepv27_decoder_parse_tlv_block last tlv 1; current block_len 0;
*Feb 18 20:15:24.569:
*Feb 18 20:15:24.569:  -curr_state Dlep In-Session State normalized_event=Dlep Peer Term
Event  p2peer=0xFFFF771137A8  peer_id=22  p2neighbor=0x0
*Feb 18 20:15:24.569:  -curr_state Dlep Terminating State normalized_event=Dlep Peer Term
ACK Event  p2peer=0xFFFF771137A8  peer_id=22  p2neighbor=0x0
*Feb 18 20:15:24.569: dlepv27_encoder_msg_packet_start DLEP_MSG_SESSION_TERM_ACK(6)
*Feb 18 20:15:24.569: dlepv27_encoder_msg_packet_end tlv block size=12 packet length=16
*Feb 18 20:15:24.570:  -curr_state Dlep Session Reset State normalized_event=Dlep Peer
sessoin reset Event  p2peer=0xFFFF771137A8  peer_id=22  p2neighbor=0x0
*Feb 18 20:15:24.570:  -0 Restart all peers on IDB GigabitEthernet0/0/1
*Feb 18 20:15:24.570: dlepv27_decoder_packet rc(RC_DLEP_OK-0) state 2 signal 0 packet_len
9
```

Step 7: An examination of the DLEP config reveals that the heartbeat on the router is set to 5 seconds:

```
Router#show dlep config
DLEP Configuration for GigabitEthernet0/0/1

DLEP Peer Description -
DLEP Version = RFC 8175
DLEP Server IP=14.0.0.3:55555
DLEPv27 TCP Port = 55556
 Virtual template=2
 Timers (all values are in seconds):
 Missed heartbeat threshold=2, Peer Terminate ACK timeout=10
 Dlepv27 Applicable configs(in seconds):
 Heartbeat interval=5, Discovery interval =5, Session Ack timeout=10
 Neighbor activity timeout=0, Neighbor Down ACK timeout=10
```

Step 8: Change the heartbeat to 60 seconds:

```
Router#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)#int g0/0/1
Router(config-if)#no ip dlep
Router(config-if)#no ip dlep vtemplate
Router(config-if)#no ip dlep vtemplate 2
Router(config-if)#ip dlep set peer-heartbeat-interval 60
Router(config-if)# ip dlep vtemplate 2
Router(config-if)#^Z
```

Step 9: Verify the change fixed the problem:

```
Router#show dlep clients

DLEP Clients for all interfaces:
```

```
DLEP Clients for Interface GigabitEthernet0/0/1
DLEP Server IP=14.0.0.3:55555 Sock=0


DLEP Client IP=14.0.0.2:859 TCP Socket fd=1
 Peer ID=51, Virtual template=2
 Description: DLEP_RadioSIM2
 Peer Timers (all values in milliseconds):
  Heartbeat=60000, Dead Interval=120000, Terminate ACK=240000
 Neighbor Timers (all values in seconds):
  Activity timeout=0, Neighbor Down ACK=10

 Supported Metrics:
  Link RLQ RX Metric : 100
  Link RLQ TX Metric : 100
  Link Resources Metric : 100
  Link MTU Metric : 100
  Link Latency Metric : 250 microseconds
  Link CDR RX Metric : 100000000 bps
  Link CDR TX Metric : 100000000 bps
  Link MDR RX Metric : 100000000 bps
  Link MDR TX Metric : 100000000 bps
Router#
*Feb 18 20:38:03.708: %SYS-5-CONFIG_P: Configured programmatically by process Manet Infra
Background from console as console
*Feb 18 20:38:03.712: %LINEPROTO-5-UPDOWN: Line protocol on Interface Virtual-Access3,
changed state to up
*Feb 18 20:38:03.716: %LINK-3-UPDOWN: Interface Virtual-Access3, changed state to up
*Feb 18 20:38:03.722: %LINEPROTO-5-UPDOWN: Line protocol on Interface vmi2, changed state
to up
```

Additional Debug Commands

The following commands are available.

Note We recommend using debug commands only when under the guidance of Cisco TAC.

DLEP

```
debug dlep server detail
debug dlep timer detail
debug dlep neighbor error
debug dlep neighbor infrastructure detail
debug dlep neighbor infrastructure error
debug dlep neighbor metrics
debug dlep neighbor state
debug dlep neighbor all
debug dlep client error
debug dlep client infrastructure
debug dlep client packet dump
debug dlep client packet detail
debug dlep client state
```

VMI

```
debug vmi bma
debug vmi packet
debug vmi error
debug vmi multicast
debug vmi neighbor
debug vmi registries
```

Virtual Template

```
debug vtemplate cloning
debug vtemplate error
debug vtemplate  event
debug vtemplate subinterface
```

PPPOE

```
debug pppoe errors
debug pppoe events
debug pppoe packets
debug pppoe data
```

SSS

```
debug sss error
debug sss event
```

Related Documentation

Additional information can be found in the following resources:

Radio Aware Routing is discussed in this Cisco white paper.

Internet Engineering Task Force (IETF) RFC 8175