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Dynamic Link Exchange Protocol (DLEP)
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Abstract

   When routing devices rely on modems to effect communications over
   wireless links, they need timely and accurate knowledge of the
   characteristics of the link (speed, state, etc.) in order to make
   forwarding decisions. In mobile or other environments where these
   characteristics change frequently, manual configurations or the
   inference of state through routing or transport protocols does not
   allow the router to make the best decisions. A bidirectional, event-
   driven communication channel between the router and the modem is
   necessary.

Status of this Memo

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<u>1</u>. Introduction

   There exist today a collection of modem devices that control links of
   variable datarate and quality. Examples of these types of links
   include line-of-sight (LOS) radios, satellite terminals, and
   cable/DSL modems. Fluctuations in speed and quality of these links
   can occur due to configuration (in the case of cable/DSL modems), or
   on a moment-to-moment basis, due to physical phenomena like multipath
   interference, obstructions, rain fade, etc. It is also quite possible
   that link quality and datarate varies with respect to individual
   destinations on a link, and with the type of traffic being sent. As
   an example, consider the case of an 802.11g access point, serving 2
   associated laptop computers. In this environment, the answer to the
   question "What is the datarate on the 802.11g link?" is "It depends
   on which associated laptop we're talking about, and on what kind of
   traffic is being sent." While the first laptop, being physically
   close to the access point, may have a datarate of 54Mbps for unicast
   traffic, the other laptop, being relatively far away, or obstructed
   by some object, can simultaneously have a datarate of only 32Mbps for
   unicast. However, for multicast traffic sent from the access point,
   all traffic is sent at the base transmission rate (which is
   configurable, but depending on the model of the access point, is
   usually 24Mbps or less).

   In addition to utilizing variable datarate links, mobile networks are
   challenged by the notion that link connectivity will come and go over
   time. Effectively utilizing a relatively short-lived connection is
   problematic in IP routed networks, as routing protocols tend to rely
   on independent timers at OSI Layer 3 to maintain network convergence
   (e.g. HELLO messages and/or recognition of DEAD routing adjacencies).
   These short-lived connections can be better utilized with an event-
   driven paradigm, where acquisition of a new neighbor (or loss of an
   existing one) is signaled, as opposed to a timer-driven paradigm.

   Another complicating factor for mobile networks are the different
   methods of physically connecting the modem devices to the router.
   Modems can be deployed as an interface card in a router's chassis, or
   as a standalone device connected to the router via Ethernet, USB, or
   even a serial link. In the case of Ethernet or serial attachment,
   with existing protocols and techniques, routing software cannot be
   aware of convergence events occurring on the radio link (e.g.
   acquisition or loss of a potential routing neighbor), nor can the
   router be aware of the actual capacity of the link. This lack of

awareness, along with the variability in datarate, leads to a
situation where quality of service (QoS) profiles are extremely
difficult to establish and properly maintain. This is especially true
of demand-based access schemes such as Demand Assigned Multiple
Access (DAMA) implementations used on some satellite systems. With a
DAMA-based system, additional datarate may be available, but will not
be used unless the network devices emit traffic at rate higher than
the currently established rate. Increasing the traffic rate does not
guarantee additional datarate will be allocated; rather, it may
result in data loss and additional retransmissions on the link.

Addressing the challenges listed above, the authors have developed
the Data Link Exchange Protocol, or DLEP. The DLEP protocol runs
between a router and its attached modem devices, allowing the modem
to communicate link characteristics as they change, and convergence
events (acquisition and loss of potential routing destinations). The
following diagrams are used to illustrate the scope of DLEP packets.

```
|-------Local Node-------|              |-------Remote Node------|
|                        |              |                        |
+--------+      +-------+        +-------+      +--------+
| Router |======| Modem |{~~~~~~~}| Modem |======| Router |
|        |      | Device|        | Device|      |        |
+--------+      +-------+        +-------+      +--------+
         |      |        | Link   |      |      |
         |-DLEP--|        | Protocol |      |-DLEP--|
         |      |        | (e.g.  |      |      |
         |      |        | 802.11) |      |      |
```
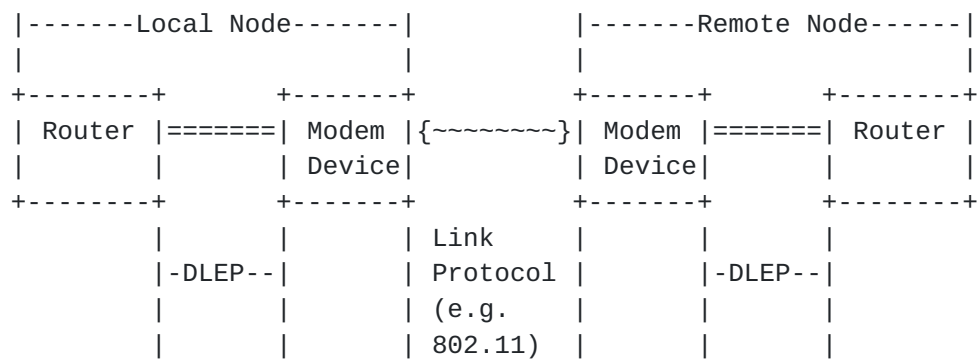
Figure 1: DLEP Network

In Figure 1, when the local modem detects the presence of a remote
node, it (the local modem) sends a signal to its router via the DLEP
protocol. Upon receipt of the signal, the local router may take
whatever action it deems appropriate, such as initiating discovery
protocols, and/or issuing HELLO messages to converge the network. On
a continuing, as-needed basis, the modem devices utilize DLEP to
report any characteristics of the link (datarate, latency, etc) that
have changed. DLEP is independent of the link type and topology
supported by the modem. Note that the DLEP protocol is specified to
run only on the local link between router and modem. Some over the
air signaling may be necessary between the local and remote modem in
order to provide some parameters in DLEP messages between the local
modem and local router, but DLEP does not specify how such over the
air signaling is carried out. Over the air signaling is purely a
matter for the modem implementer.

Figure 2 shows how DLEP can support a configuration where routers are

connected with different link types. In this example, Modem A
implements a point-to-point link, and Modem B is connected via a
shared medium. In both cases, the DLEP protocol is used to report the
characteristics of the link (datarate, latency, etc.) to routers. The
modem is also able to use the DLEP session to notify the router when
the remote node is lost, shortening the time required to re-converge
the network.

```
            +--------+                      +--------+
        +----+ Modem A|                      | Modem A+---+
        |    | Device |  <===== // ======>   | Device |   |
        |    +--------+     P-2-P Link       +--------+   |
    +---+----+                                        +---+----+
    | Router |                                        | Router |
    |        |                                        |        |
    +---+----+                                        +---+----+
        |      +--------+                  +--------+   |
        +-----+ Modem B|                   | Modem B|   |
              | Device |  o o o o o o o o   | Device +--+
              +--------+    o  Shared   o   +--------+
                           o Medium  o
                            o       o
                             o     o
                              o   o
                               o
                          +--------+
                          | Modem B|
                          | Device |
                          +---+----+
                              |
                              |
                          +---+----+
                          | Router |
                          |        |
                          +--------+
```
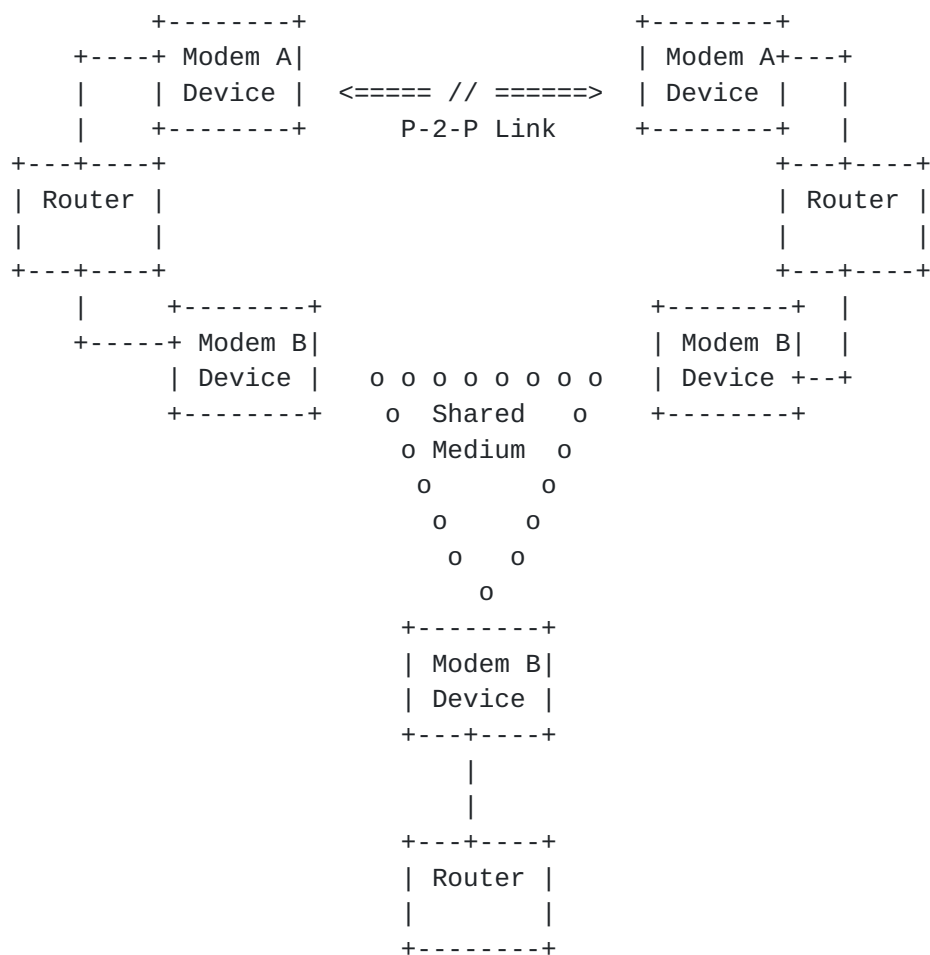
                 Figure 2: DLEP Network with Multiple Modem Devices

   DLEP defines a set of messages used by modems and their attached
   routers. The messages are used to communicate events that occur on
   the physical link(s) managed by the modem: for example, a remote node

entering or leaving the network, or that the link has changed.
Associated with these messages are a set of data items - information
that describes the remote node (e.g., address information), and/or
the characteristics of the link to the remote node.

The protocol is defined as a collection of type-length-value (TLV)
based messages, specifying the signals that are exchanged between a
router and a modem, and the data items associated with the signal.
This document specifies transport of DLEP signals and data items via
the TCP transport, with a UDP-based discovery mechanism. Other
transports for the protocol are possible, but are outside the scope
of this document.

DLEP signals are further defined as mandatory or optional. Signals
will additionally have mandatory and optional data items.
Implementations MUST support all mandatory messages and their
mandatory data items to be considered compliant. Implementations MAY
also support some, or all, of the optional messages and data items.

DLEP uses a session-oriented paradigm between the modem device and
its associated router. If multiple modem devices are attached to a
router (as in Figure 2), a separate DLEP session MUST exist for each
modem. If a modem device supports multiple connections to a router
(via multiple logical or physical interfaces), or supports
connections to multiple routers, a separate DLEP session MUST exist
for each connection. This router/modem session provides a carrier for
information exchange concerning "destinations" that are available via
the modem device. A "destination" can be either physical (as in the
case of a specific far-end router), or a logical destination (as in a
Multicast group). As such, all of the destination-level exchanges in
DLEP can be envisioned as building an information base concerning the
remote nodes, and the link characteristics to those nodes.

Multicast traffic destined for the variable-quality network (the
network accessed via the DLEP modem) is handled in IP networks by
deriving a Layer 2 MAC address based on the Layer 3 address.
Leveraging on this scheme, Multicast traffic is supported in DLEP
simply by treating the derived MAC address as any other "destination"
(albeit a logical one) in the network. To support these logical
destinations, one of the DLEP participants (typically, the router)
informs the other as to the existence of the logical neighbor. The
modem, once it is aware of the existence of this logical neighbor,
reports link characteristics just as it would for any other
destination in the network. The specific algorithms a modem would use
to report metrics on multicast (or logical) destinations is outside
the scope of this specification, and is left to specific
implementations to decide.

1.1 Requirements

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in BCP 14, RFC 2119 [RFC2119].

2. Assumptions

Routers and modems that exist as part of the same node (e.g., that are locally connected) can utilize a discovery technique to locate each other, thus avoiding a-priori configuration. The modem is responsible for initialing the discovery process, using the Peer Discovery message.

DLEP utilizes a session-oriented paradigm. A router and modem form a session by completing the discovery process. This router-modem session persists unless or until it either (1) times out, based on the timeout values supplied, or (2) is explicitly torn down by one of the participants. Note that while use of timers in DLEP is OPTIONAL, it is strongly recommended that implementations choose to run with timers enabled.

DLEP assumes that participating modems, and their physical links, act as a transparent bridge. Specifically, the assumption is that the destination MAC address for data traffic in any frame emitted by the router should be the MAC address of a device in the remote node. DLEP also assumes that MAC addresses are unique within the context of the router-modem session.

This document refers to a remote node as a "Destination". Destinations can be identified by either the router or the modem, and represent a specific destination (e.g., an address) that exists on the link(s) managed by the modem. A destination MUST contain a MAC address, it MAY optionally include a Layer 3 address (or addresses). Destinations MAY refer either to physical devices in the network, or to logical destinations, as in a multicast group. As "destinations" are discovered, DLEP routers and modems build an information base on destinations accessible via the modem. Changes in link characteristics MAY then be reported as being "modem-wide" (effecting ALL destinations accessed via the modem) or MAY be neighbor (destination) specific.

The DLEP messages concerning destinations thus become the way for routers and modems to maintain, and notify each other about, an information base representing the physical and logical (e.g., multicast) destinations accessible via the modem device. The information base would contain addressing information (e.g., MAC

address, and OPTIONALLY, Layer 3 addresses), link characteristics
(metrics), and OPTIONALLY, flow control information (credits).

DLEP assumes that security on the session (e.g. authentication of
session partners, encryption of traffic, or both) is dealt with by
the underlying transport mechanism (e.g., by using a transport such
as TLS [TLS]).

This document specifies an implementation of the DLEP messages and
data items running over the TCP transport, utilizing a well-known TCP
Port number. It is assumed that DLEP running over other transport
mechanisms would be documented separately.

3. Credits

DLEP includes an OPTIONAL credit-windowing scheme analogous to the
one documented in [RFC5578]. In this scheme, traffic between the
router and modem is treated as two unidirectional windows. This
document identifies these windows as the "Modem Receive Window", or
MRW, and the "Router Receive Window", or RRW.

If credits are used, they MUST be granted by the receiver on a given
window - that is, on the "Modem Receive Window" (MRW), the modem is
responsible for granting credits to the router, allowing it (the
router) to send data to the modem. Likewise, the router is
responsible for granting credits on the RRW, which allows the modem
to send data to the router.

DLEP expresses all credit data in number of octets. The total number
of credits on a window, and the increment to add to a grant, are
always expressed as a 64-bit unsigned quantity.

If used, credits are managed on a neighbor-specific basis; that is,
separate credit counts are maintained for each neighbor requiring the
service. Credits do not apply to the DLEP session that exists between
routers and modems.

4. Metrics

DLEP includes the ability for the router and modem to communicate
metrics that reflect the characteristics (e.g. datarate, latency) of
the variable-quality link in use. DLEP does NOT specify how a given
metric value is to be calculated, rather, the protocol assumes that
metrics have been calculated with a "best effort", incorporating all
pertinent data that is available to the modem device.

As mentioned in the introduction section of this document, metrics

have to be used within a context - for example, metrics to a unicast
address in the network. DLEP allows for metrics to be sent within two
contexts - metrics for a specific destination within the network
(e.g., a specific router), and "modem-wide" (those that apply to all
destinations accessed via the modem). Metrics are further subdivided
into transmit and receive metrics. Metrics supplied on DLEP Peer
signals are, by definition, modem-wide; metrics supplied on
Destination messages signals are, by definition, used for the
specific neighbor only.

DLEP modem implementations MUST announce all supported metric items,
and provide default values for those metrics, in the Peer
Initialization message. In order to introduce a new metric type, DLEP
modem implementations MUST terminate the session with the router (via
the Peer Terminate message), and re-establish the session.

It is left to implementations to choose sensible default values based
on their specific characteristics. Modems having static (non-
changing) link metric characteristics MAY report metrics only once
for a given neighbor (or once on a modem-wide basis, if all
connections via the modem are of this static nature).

The approach of allowing for different contexts for metric data
increases both the flexibility and the complexity of using metric
data. This document details the mechanism whereby the data is
transmitted, however, the specific algorithms (precedence, etc) for
utilizing the dual-context metrics is out of scope and not addressed
by this document.

5. Extensions to DLEP

While this draft represents the best efforts of the co-authors, and
the working group, to be functionally complete, it is recognized that
extensions to DLEP will in all likelihood be necessary as more link
types are utilized. To allow for future innovation, the draft
allocates numbering space for experimental implementations of both
signals and data items.

DLEP implementations MUST be capable of parsing and acting on the
mandatory messages and data items as documented in this
specification. DLEP messages/data items that are optional, or are in
the experimental numbering range SHOULD be silently dropped by an
implementation if they are not understood.

The intent of the optional messages and data items, as well as the
experimental numbering space, is to allow for further development of
DLEP protocol features and function. Having experimental space
reserved for both signals and data items gives maximum flexibility

for extending the protocol as conditions warrant. For example,
experimental data items could be used by implementations to send
additional metrics. A combination of experimental messages, and
associated data items, could be used to implement new flow control
schemes. If subsequent research and development define new features
and function, then it should be standardized either as an update to
this document, or as an additional stand-alone specification.

[6](#). Normal Session Flow

Normal session flow is slightly different, depending on whether the
implementation represents a modem or a router, and whether discovery
techniques are used. The normal flow by DLEP partner type is:

[6.1](#) DLEP Modem session flow - Discovery case

If the DLEP modem implementation is utilizing the optional discovery
mechanism, then the implementation will initialize a UDP socket,
binding it to an arbitrary port. This UDP socket is used to send the
Peer Discovery message to the DLEP link-local multicast address and
port (TBD). The implementation then waits on receipt of a Peer Offer
message, which MUST contain the unicast address and port for TCP-
based communication with a DLEP router. The Peer Offer message MAY
contain multiple address/port combinations. If more than one
address/port combination is in the Peer Offer, the DLEP modem
implementation SHOULD consider the list to be in priority sequence,
with the "most desired" address/port combination listed first.
However, modem implementations MAY use their own heuristics to
determine the best address/port combination. At this point, the modem
implementation MAY either destroy the UDP socket, or continue to
issue Peer Discovery messages to the link-local address/port
combination. In either case, the TCP session initialization occurs as
in the configured case.

[6.2](#) DLEP Modem session flow - Configured case

When a DLEP modem implementation has the address and port information
for a TCP connection to the router (obtained either via configuration
or via the discovery process described above), the modem will
initialize and bind a TCP socket. This socket is used to connect to
the DLEP router software. After a successful TCP connect, the modem
implementation MUST issue a Peer Initialization message to the DLEP
router. The Peer Initialization message MUST contain TLVs for ALL
supported metrics from this modem (e.g. all MANDATORY metrics plus
all OPTIONAL metrics supported by the implementation), along with the
default values of those metrics. After sending the Peer
Initialization, the modem implementation should wait for receipt of a

Peer Initialization ACK message from the router. Receipt of the Peer
Initialization ACK indicates that the router has received and
processed the Peer Initialization, and the session MUST transition to
the "in session" state. At this point, messages regarding
destinations in the network, and/or Peer Update messages, can flow on
the DLEP session between modem and router. The "in session" state is
maintained until one of the following conditions occur:

o The session is explicitly terminated (using Peer Termination), or
o The session times out, based on supplied timeout values.

6.3 DLEP Router session flow

DLEP router implementations MUST support the discovery mechanism.
Therefore, the normal flow is as follows:

The implementation will initialize a UDP socket, binding that socket
to the DLEP link-local multicast address (TBD) and the DLEP well-
known port number (also TBD). The implementation will then initialize
a TCP socket, on a unicast address and port. This socket is used to
listen for incoming TCP connection requests.

When the router implementation receives a Peer Discovery message on
the UDP socket, it responds by issuing a Peer Offer message to the
sender of the Peer Discovery. The Peer Offer message MUST contain the
unicast address and port of the TCP listen socket, described above. A
DLEP router implementation MAY respond with ALL address/port
combinations that have an active TCP listen posted. If multiple
address/port combinations are listed, the receiver of the Peer Offer
MAY connect on any available address/port pair. Anything other than
Peer Discovery messages received on the UDP socket MUST be silently
dropped.

When the DLEP router implementation accepts a connection via TCP, it
will wait for receipt of a Peer Initialization message. The received
Peer Initialization MUST contain metric TLVs for ALL mandatory
metrics, and MUST contain metric TLVs for ANY optional metrics
supported by the modem. If a new metric is to be introduced, the DLEP
session between router and modem MUST be terminated and restarted,
and the new metric described in a Peer Initialization message.

6.4 Common Session Flow

In order to maintain the session between router and modem, periodic
"Heartbeat" messages SHOULD be exchanged. These messages are intended
to keep the session alive, and to verify bidirectional connectivity

between the two participants. DLEP also provides for an OPTIONAL Peer
Update message, intended to communicate some change in status (e.g.,
a change of layer 3 address parameters, or a modem-wide link change).

In addition to the messages above, the participants will transmit
DLEP messages concerning destinations in the network. These messages
trigger creation/maintenance/deletion of destinations in the
information base of the recipient. For example, a modem will inform
its attached router of the presence of a new destination via the
"Destination Up" signal. Receipt of a Destination Up causes the
router to allocate the necessary resources, creating an entry in the
information base with the specifics (e.g., MAC Address, Latency, Data
Rate, etc) of the neighbor. The loss of a destination is communicated
via the "Neighbor Down" signal, and changes in status to the
destination (e.g. varying link quality, or addressing changes) are
communicated via the "Neighbor Update" signal. The information on a
given neighbor will persist in the router's information base until
(1) a "Neighbor Down" is received, indicating that the modem has lost
contact with the remote node, or (2) the router/modem session
terminates, indicating that the router has lost contact with its own
local modem.

Again, metrics can be expressed within the context of a specific
neighbor via the Neighbor Update message, or on a modem-wide basis
via the Peer Update message. In cases where metrics are provided on
the router/modem session, the receiver MUST propagate the metrics to
all destinations in its information base that are accessed via the
originator. A DLEP participant MAY send metrics both in a
router/modem session context (via the Peer Update message) and a
specific neighbor context (via Neighbor Update) at any time. The
heuristics for applying received metrics is left to implementations.

In addition to receiving metrics about the link, DLEP provides an
OPTIONAL signal allowing a router to request a different datarate, or
latency, from the modem. This signal is referred to as the Link
Characteristics Message, and gives the router the ability to deal
with requisite increases (or decreases) of allocated datarate/latency
in demand-based schemes in a more deterministic manner.

7. **Mandatory Signals and Data Items**

The following DLEP signals are considered core to the specification;
implementations MUST support these signals, and the associated data
items, in order to be considered compliant:

```
        Signal                      Data Items
        ======                      ==========
        Peer Discovery (Modem Only)   DLEP Version
```

```
          Peer Offer (Router Only)      DLEP Version
                                        IPv4 or IPv6 address(es)
                                        DLEP Port

          Peer Initialization           DLEP Version
                                        Maximum Data Rate (Receive)
                                        Maximum Data Rate (Transmit)
                                        Current Data Rate (Receive)
                                        Current Data Rate (Transmit)
                                        Latency
                                        Relative Link Quality (Receive)
                                        Relative Link Quality (Transmit)

          Peer Initialization ACK       Status

          Peer Termination              None

          Peer Termination ACK          Status

          Destination Up                MAC Address
                                        Maximum Data Rate (Receive)
                                        Maximum Data Rate (Transmit)
                                        Current Data Rate (Receive)
                                        Current Data Rate (Transmit)
                                        Latency
                                        Relative Link Quality (Receive)
                                        Relative Link Quality (Transmit)

          Destination Update            MAC Address
                                        Maximum Data Rate (Receive)
                                        Maximum Data Rate (Transmit)
                                        Current Data Rate (Receive)
                                        Current Data Rate (Transmit)
                                        Latency
                                        Relative Link Quality (Receive)
                                        Relative Link Quality (Transmit)

          Destination Down              MAC Address
```

   All other DLEP signals and data items are OPTIONAL. Implementations
   MAY choose to provide them. Implementations that do not support
   optional signals and data items SHOULD parse, and silently drop, all
   unsupported messages and/or data items.

[8]. Generic DLEP Message Definition

   The Generic DLEP Message consists of a sequence of TLVs. The first
   TLV represents the signal being communicated (e.g., a "Destination

Up", or a "Peer Offer"). Subsequent TLVs contain the data items
pertinent to the signal (e.g., Maximum Data Rate, or Latency, etc).

The Generic DLEP Packet Definition contains the following fields:

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|Signal TLV Type | Length               | DLEP data items...   |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

```
   Signal              - One of the DLEP Message TLV type values
                          defined in this document.

   Length              - The length, expressed as a 16-bit
                          quantity, of all of the DLEP data items
                          associated with this signal.

   DLEP data items     - One or more data items, encoded in TLVs,
                          as defined in this document.
```

9. DLEP Data Items

As mentioned earlier, DLEP protocol messages are transported as a
collection of TLVs. The first TLV present in a DLEP message MUST be
one of the Signal TLVs, documented in section 10. The signals are
followed by one or more data items, indicating the specific changes
that need to be instantiated in the receiver's information base.

Valid DLEP Data Items are:

```
        TLV       TLV
        Value     Description
        ======================================
        TBD       DLEP Version
        TBD       DLEP Port
        TBD       Peer Type
        TBD       IPv4 Address
        TBD       IPv6 Address
        TBD       Maximum Data Rate (Receive)  (MDRR)
        TBD       Maximum Data Rate (Transmit) (MDRT)
        TBD       Current Data Rate (Receive)  (CDRR)
        TBD       Current Data Rate (Transmit) (CDRT)
        TBD       Latency
        TBD       Receive Resources
        TBD       Transmit Resources
```

```
        TBD      Expected Forwarding Time (EFT)
        TBD      Relative Link Quality (Receive)  (RLQR)
        TBD      Relative Link Quality (Transmit) (RLQT)
        TBD      Status
        TBD      Heartbeat Interval/Threshold
        TBD      Neighbor down ACK timer
        TBD      Link Characteristics ACK timer
        TBD      Credit Window Status
        TBD      Credit Grant
        TBD      Credit Request
```

DLEP data item TLVs contain the following fields:

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|  TLV Type     | Length       | Value...                      |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

TLV Type   - An 8-bit unsigned integer field specifying the data
               item being sent.

Length   - An 8-bit length of the value field of the data item

Value   - A field of length <Length> which contains data
               specific to a particular data item.

9.1 DLEP Version

The DLEP Version TLV is a MANDATORY TLV in Peer Discovery, Peer
Offer, and Peer Initialization messages. The Version TLV is used to
indicate the version of the protocol running in the sender. The
receiver SHOULD use this information to decide if the potential
session partner is running at a supported level.

The DLEP Version TLV contains the following fields:

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|TLV Type =TBD  |Length=4       |          Major Version        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|        Minor Version          |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

TLV Type   - TBD

Length   - Length is 4

Major Version - Major version of the modem or router protocol.

Minor Version - Minor version of the modem or router protocol.

Support of this draft is indicated by setting the Major Version
to '1', and the Minor Version to '5' (i.e. Version 1.5).

9.2 DLEP Port

The DLEP Port TLV is a MANDATORY TLV in the Peer Offer message. The
DLEP Port TLV is used to indicate the TCP Port number on the DLEP
server available for connections. The receiver MUST use this
information to perform the TCP connect to the DLEP server.

The DLEP Port TLV contains the following fields:

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|TLV Type =TBD  |Length=2       |        TCP Port Number        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

TLV Type   - TBD

Length   - Length is 2

TCP Port Number - TCP Port number on the DLEP server.

Minor Version - Minor version of the modem or router protocol.

9.3 Peer Type

The Peer Type TLV is an OPTIONAL TLV in both the Peer Discovery and
Peer Offer messages. The Peer Type TLV is used by the router and
modem to give additional information as to its type. The peer type is
a string and is envisioned to be used for informational purposes
(e.g. as output in a display command).

The Peer Type TLV contains the following fields:

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|TLV Type =TBD  |Length= peer   |Peer Type String               |
```

```
|                   |type string len|                               |
  +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

   TLV Type   - TBD

   Length   - Length of peer type string.

   Peer Type String - Non-Null terminated string, using UTF-8 encoding.
                      For example, a satellite modem might set this
                      variable to 'Satellite terminal'.

9.4 MAC Address

   The MAC address TLV MUST appear in all destination-oriented signals
   (e.g. Destination Up, Destination Up ACK, Destination Down,
   Destination Down ACK, Destination Update, Link Characteristics
   Request, and Link Characteristics ACK). The MAC Address TLV contains
   the address of the destination on the remote node. The MAC address
   MAY be either a physical or a virtual destination. Examples of a
   virtual destination would be a multicast MAC address, or the
   broadcast MAC (0xFFFFFFFFFFFF).

```
    0                   1                   2                   3
    0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |TLV Type =TBD  |Length = 6     |          MAC Address          |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                        MAC Address                            |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

   TLV Type   - TBD

   Length   - 6

   MAC Address - MAC Address of the destination (either physical or
                 virtual).

9.5 IPv4 Address

   The IPv4 Address TLV is an OPTIONAL TLV. If supported, it MAY appear
   in Destination Up, Destination Update, and Peer Update messages. When
   included in Destination messages, the IPv4 Address TLV contains the
   IPv4 address of the destination, as well as a subnet mask value. In
   the Peer Update message, it contains the IPv4 address of the
   originator of the message. In either case, the TLV also contains an
   indication of whether this is a new or existing address, or is a
   deletion of a previously known address.

The IPv4 Address TLV contains the following fields:

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|TLV Type =TBD  |Length = 6     |   Add/Drop    | IPv4 Address  |
|               |               |   Indicator   |               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|             IPv4 Address                      |  Subnet Mask  |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```
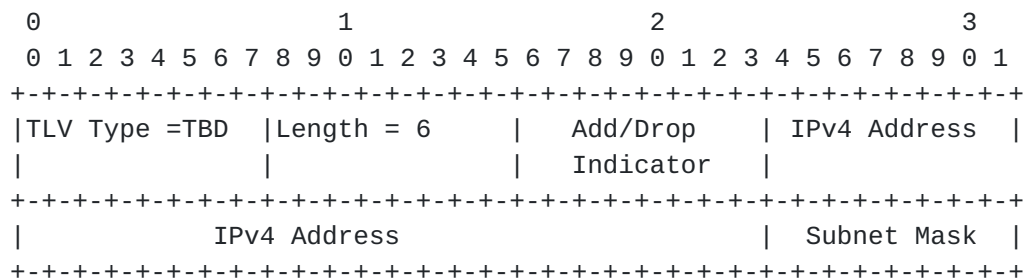
    TLV Type   - TBD

    Length   - 6

    Add/Drop   - Value indicating whether this is a new or existing
                   address (0x01), or a withdrawal of an address (0x02).

    IPv4 Address - The IPv4 address of the destination or peer.

    Subnet Mask - A subnet mask (0-32) to be applied to the IPv4
                   address.

9.6 IPv6 Address

   The IPv6 Address TLV is an OPTIONAL TLV. If supported, it MAY be used
   in the Destination Up, Destination Update, Peer Discovery, and Peer
   Update Messages. When included in Destination messages, this data
   item contains the IPv6 address of the destination. In the Peer
   Discovery and Peer Update, it contains the IPv6 address of the
   originating peer. In either case, the data item also contains an
   indication of whether this is a new or existing address, or is a
   deletion of a previously known address, as well as a subnet mask.

   The IPv6 Address TLV contains the following fields:

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|TLV Type =TBD  |Length = 18    |   Add/Drop    | IPv6 Address  |
|               |               |   Indicator   |               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                        IPv6 Address                           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                        IPv6 Address                           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                        IPv6 Address                           |
```

```
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                    IPv6 Address                |  Subnet Mask  |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

TLV Type   - TBD

Length   - 18

Add/Drop   - Value indicating whether this is a new or existing
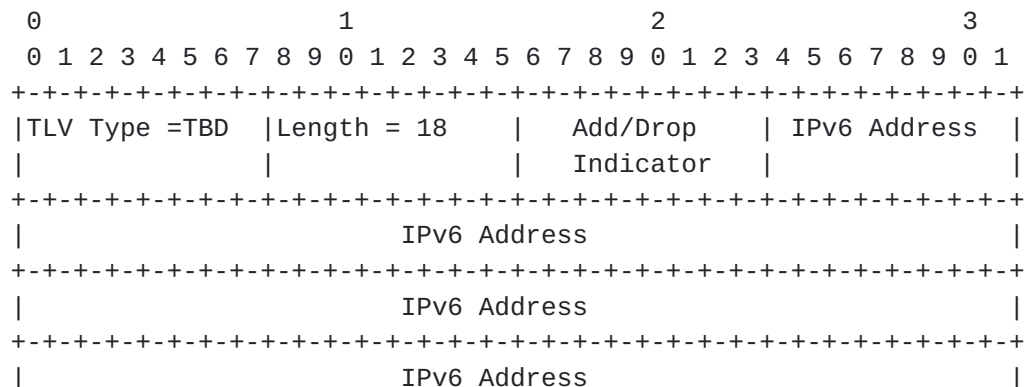   address (0x01), or a withdrawal of an address (0x02).

IPv6 Address - IPv6 Address of the destination or peer.

Subnet Mask - A subnet mask value (0-128) to be applied to the Ipv6
               address.

9.7 **Maximum Data Rate (Receive)**

The Maximum Data Rate Receive (MDRR) TLV is used in Destination Up,
Destination Update, Peer Discovery, Peer Update, and Link
Characteristics ACK Messages to indicate the maximum theoretical data
rate, in bits per second, that can be achieved while receiving data
on the link. When metrics are reported via the messages listed above,
the maximum data rate receive MUST be reported.

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|TLV Type =TBD  |Length = 8     |          MDRR (bps)           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                           MDRR (bps)                          |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|          MDRR (bps)           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

TLV Type   - TBD

Length   - 8

Maximum Data Rate Receive - A 64-bit unsigned number, representing
                    the maximum theoretical data rate, in bits per
                    second (bps), that can be achieved while
                    receiving on the link.

9.8 **Maximum Data Rate (Transmit)**

The Maximum Data Rate Transmit (MDRT) TLV is used in Destination Up, Destination Update, Peer Discovery, Peer Update, and Link Characteristics ACK Messages to indicate the maximum theoretical data rate, in bits per second, that can be achieved while transmitting data on the link. When metrics are reported via the messages listed above, the maximum data rate transmit MUST be reported.

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|TLV Type =TBD  |Length = 8     |            MDRT (bps)         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                           MDRT (bps)                          |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|            MDRT (bps)          |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

TLV Type   -   TBD

Length   -   8

Maximum Data Rate Transmit - A 64-bit unsigned number, representing
                    the maximum theoretical data rate, in bits per
                    second (bps), that can be achieved while
                    transmitting on the link.

9.9 Current Data Rate (Receive)

The Current Data Rate Receive (CDRR) TLV is used in Destination Up, Destination Update, Peer Discovery, Peer Update, Link Characteristics Request, and Link Characteristics ACK messages to indicate the rate at which the link is currently operating for receiving traffic. The Current Data Rate Receive is a MANDATORY data item. In the case of the Link Characteristics Request, CDRR represents the desired receive data rate for the link. When metrics are reported via the messages above (e.g. Destination Update), the current data rate receive MUST be reported.

The Current Data Rate Receive TLV contains the following fields:

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|TLV Type =TBD  |TLV Flags=0x10 |Length = 8     |CDRR (bps)     |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                           CDRR (bps)                          |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

```
|                       CDRR (bps)             |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

TLV Type   - TBD

Length   - 8

Current Data Rate Receive - A 64-bit unsigned number, representing
                             the current data rate, in bits per second, that
                             is currently be achieved while receiving traffic
                             on the link. When used in the Link
                             Characteristics Request, CDRR represents the
                             desired receive rate, in bits per second, on the
                             link. If there is no distinction between current
                             and maximum receive data rates, current data
                             rate receive SHOULD be set equal to the maximum
                             data rate receive.

9.10 **Current Data Rate (Transmit)**

The Current Data Rate Receive (CDRT) TLV is used in Destination Up,
Destination Update, Peer Discovery, Peer Update, Link Characteristics
Request, and Link Characteristics ACK messages to indicate the rate
at which the link is currently operating for transmitting traffic.
Current Data Rate Transmit is a MANDATORY data item. In the case of
the Link Characteristics Request, CDRT represents the desired
transmit data rate for the link. When metrics are reported via the
messages above (e.g. Destination Update), the current data rate
transmit MUST be reported.

The Current Data Rate Transmit TLV contains the following fields:

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|TLV Type =TBD  |TLV Flags=0x10 |Length = 8     |CDRT (bps)     |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                       CDRT (bps)                              |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                       CDRT (bps)             |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

TLV Type   - TBD

Length   - 8

Current Data Rate Transmit - A 64-bit unsigned number, representing

the current data rate, in bits per second, that
is currently be achieved while transmitting
traffic on the link. When used in the Link
Characteristics Request, CDRT represents the
desired transmit rate, in bits per second, on
the link. If there is no distinction between
current and maximum transmit data rates, current
data rate transmit MUST be set equal to the
maximum data rate transmit.

9.11 Expected Forwarding Time

The Expected Forwarding Time (EFT) TLV is is an OPTIONAL data item.
If supported, it MAY be used in Destination Up, Destination Update,
Peer Discovery, and Peer Update messages to indicate the typical
latency between the arrival of a given packet at the transmitting
device and the reception of the packet at the other end of the link.
EFT combines transmission time, idle time, waiting time, freezing
time, and queuing time to the degree that those values are meaningful
to a given transmission medium.

The Expected Forwarding Time TLV contains the following fields:

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|TLV Type =TBD  |Length = 4     |          EFT (ms)             |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|          EFT (ms)             |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

TLV Type   -   TBD

Length   -   4

EFT   -   A 32-bit unsigned number, representing the expected
                 forwarding time, in milliseconds, on the link.

9.12 Latency

The Latency TLV is an MANDATORY data item. It is used in Peer
Initialization, Destination Up, Destination Update, Peer Discovery,
Peer Update, Link Characteristics Request, and Link Characteristics
ACK messages to indicate the amount of latency on the link, or in the
case of the Link Characteristics Request, to indicate the maximum
latency required on the link.

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|TLV Type =TBD  |Length = 2     |           Latency (ms)        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

TLV Type   -   TBD

Length   -   2

Latency   -   A 16-bit unsigned value, representing the transmission
                 delay that a packet encounters as it is transmitted
                 over the link. In Destination Up, Destination Update,
                 and Link Characteristics ACK, this value is reported
                 as delay, in milliseconds. The calculation of latency
                 is implementation dependent. For example, the latency
                 may be a running average calculated from the internal
                 queuing. If a device cannot calculate latency, this
                 TLV SHOUD NOT be issued. In the Link Characteristics
                 Request Message, this value represents the maximum
                 delay, in milliseconds, expected on the link.

9.13 **Resources (Receive)**

   The Receive Resources TLV is an OPTIONAL data item. If supported, it
   is used in Destination Up, Destination Update, Peer Discovery, Peer
   Update, and Link Characteristics ACK messages to indicate a
   percentage (0-100) amount of resources (e.g. battery power),
   committed to receiving data, remaining on the originating peer.

   The Resources TLV contains the following fields:

```
 0                   1                   2
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|TLV Type =TBD  |Length = 1     | Rcv Resources|
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

TLV Type   -   TBD

Length   -   1

Receive Resources   - A percentage, 0-100, representing the amount
                 of remaining resources, such as battery power,
                 allocated to receiving data. If a device cannot
                 calculate receive resources, this TLV SHOULD NOT be
                 issued.

9.14 Resources (Transmit)

   The Transmit Resources TLV is an OPTIONAL data item. If supported, it
   is used in Destination Up, Destination Update, Peer Discovery, Peer
   Update, and Link Characteristics ACK messages to indicate a
   percentage (0-100) amount of resources (e.g. battery power),
   committed to transmitting data, remaining on the originating peer.

   The Resources TLV contains the following fields:

```
 0                   1                   2
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|TLV Type =TBD  |Length = 1     | Xmt Resources|
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

   TLV Type   -   TBD

   Length   -   1

   Transmit Resources   -   A percentage, 0-100, representing the amount
                   of remaining resources, such as battery power,
                   allocated to transmitting data. If the transmit
                   resources cannot be calculated, then the TLV SHOULD
                   NOT be issued.

9.15 Relative Link Quality (Receive)

   The Relative Link Quality Receive (RLQR) TLV is a MANDATORY data
   item. If supported, it is used in Peer Initialization, Destination
   Up, Destination Update, Peer Discovery, Peer Update, and Link
   Characteristics ACK messages to indicate the quality of the link for
   receiving data as calculated by the originating peer.

   The Relative Link Quality (Receive) TLV contains the following
   fields:

```
 0                   1                   2
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|TLV Type =TBD  |Length = 1     |RCV Rel. Link  |
|               |               |Quality (RLQR) |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

   TLV Type   -   TBD

Length   - 1

Relative Link Quality (Receive) - A non-dimensional number, 1-100,
                         representing relative link quality. A value of
                         100 represents a link of the highest quality.
                         If a device cannot calculate the RLQR, this
                         TLV SHOULD NOT be issued.

9.16 Relative Link Quality (Transmit)

The Transmit Link Quality Receive (RLQT) TLV is a MANDATORY data
item. It is used in Peer Initialization, Destination Up, Destination
Update, Peer Discovery, Peer Update, and Link Characteristics ACK
messages to indicate the quality of the link for transmitting data as
calculated by the originating peer.

The Relative Link Quality (Transmit) TLV contains the following
fields:

```
 0                   1                   2
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|TLV Type =TBD  |Length = 1     |XMT Rel. Link  |
|               |               |Quality (RLQR) |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

TLV Type   - TBD

Length   - 1

Relative Link Quality (Transmit) - A non-dimensional number, 1-100,
                         representing relative link quality. A value of
                         100 represents a link of the highest quality.
                         If a device cannot calculate the RLQT, this
                         TLV SHOULD NOT be issued.

9.17 Status

The Status TLV is sent as part of an acknowledgement message, from
either the modem or the router, to indicate the success or failure of
a given request.

The Status TLV contains the following fields:

```
 0                   1                   2
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3
```

```
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|TLV Type =TBD  |Length = 1     |      Code     |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

TLV Type   - TBD

Length   - 1

Termination Code - 0 = Success, Non-zero = Failure. Specific values
                    of a non-zero termination code depend on the
                    operation requested (e.g. Destination Up,
                    Destination Down, etc).

9.18 Heartbeat Interval

The Heartbeat Interval TLV is a MANDATORY TLV. It MUST be sent during
Peer Initialization to indicate the desired Heartbeat timeout window.
The router MUST either accept the timeout interval supplied by the
modem, or reject the Peer Initialization, and close the socket.
Implementations MUST implement heuristics such that DLEP signals
sent/received reset the timer interval.

The Interval is used to specify a period (in seconds) for Heartbeat
Messages (See Section 23). By specifying an Interval value of 0,
implementations MAY indicates the desire to disable Heartbeat
messages entirely (e.g., the Interval is set to an infinite value),
however, it is strongly recommended that implementations use non 0
timer values.

A DLEP session will be considered inactive, and MUST be torn down, by
an implementation detecting that two (2) Heartbeat intervals have
transpired without receipt of any DLEP messages.

The Heartbeat Interval TLV contains the following fields:

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|TLV Type =TBD  |Length = 2     |           Interval            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

TLV Type   - TBD

Length   - 2

Interval   - 0 = Do NOT use heartbeats on this peer-to-peer
                    session. Non-zero = Interval, in seconds, for

                         heartbeat messages.

9.19 Link Characteristics ACK Timer

   The Link Characteristics ACK Timer TLV is an OPTIONAL TLV. If
   supported, it MAY be sent during Peer Initialization to indicate the
   desired number of seconds to wait for a response to a Link
   Characteristics Request. If a router receives this TLV from a modem
   during Peer Discovery, the router MUST either accept the timeout
   value, or reject the Peer Discovery. If this TLV is omitted,
   implementations supporting the Link Characteristics Request SHOULD
   choose a default value.

   The Link Characteristics ACK Timer TLV contains the following fields:

```
 0                   1                   2
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|TLV Type =TBD  |Length = 1     | Interval      |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

   TLV Type   - TBD

   Length   - 1

   Interval   - 0 = Do NOT use timeouts for Link Characteristics
                   requests on this router/modem session. Non-zero =
                   Interval, in seconds, to wait before considering a
                   Link Characteristics Request has been lost.

9.20 Credit Window Status

   The Credit Window Status TLV is an OPTIONAL TLV. If credits are
   supported by the DLEP participants (both the router and the modem),
   the Credit Window Status TLV MUST be sent by the participant
   receiving a Credit Grant Request for a given destination.

   The Credit Window Status TLV contains the following fields:

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|TLV Type =TBD  |Length = 16    | Modem Receive Window Value    |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                    Modem Receive Window Value                 |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|   Modem Receive Window Value   | Router Receive Window Value   |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

```
|                    Router Receive Window Value                |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|  Router Receive Window Value  |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

TLV Type   - TBD

Length   - 16

Modem Receive Window Value - A 64-bit unsigned number, indicating
                              the current (or initial) number of
                              credits available on the Modem Receive
                              Window.

Router Receive Window Value - A 64-bit unsigned number, indicating
                              the current (or initial) number of
                              credits available on the Router Receive
                              Window.

9.21 Credit Grant Request

The Credit Grant Request TLV is an OPTIONAL TLV. If credits are
supported, the Credit Grant Request TLV is sent from a DLEP
participant to grant an increment to credits on a window. The Credit
Grant TLV is sent as a data item in either the Destination Up or
Destination Update messages. The value in a Credit Grant TLV
represents an increment to be added to any existing credits available
on the window. Upon successful receipt and processing of a Credit
Grant TLV, the receiver MUST respond with a message containing a
Credit Window Status TLV to report the updated aggregate values for
synchronization purposes.

In the Destination Up message, when credits are desired, the
originating peer MUST set the initial credit value of the window it
controls (e.g. the Modem Receive Window, or Router Receive Window) to
an initial, non-zero value. If the receiver of a Destination Up
message with a Credit Grant Request TLV supports credits, the
receiver MUST either reject the use of credits, via a Destination Up
ACK response with the correct Status TLV, or set the initial value
from the data contained in the Credit Window Status TLV. If the
initialization completes successfully, the receiver MUST respond to
the Destination Up message with a Destination Up ACK message that
contains a Credit Window Status TLV, initializing its receive window.

The Credit Grant TLV contains the following fields:

```
 0                   1                   2                   3
```

```
  0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |TLV Type =TBD  |Length = 8     |        Credit Increment       |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |                         Credit Increment                      |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |      Credit Increment         |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

TLV Type   - TBD

Length   - 8

Reserved   - A 64-bit unsigned number representing the
                    additional credits to be assigned to the credit
                    window. Since credits can only be granted by the
                    receiver on a window, the applicable credit window
                    (either the MRW or the RRW) is derived from the
                    sender of the grant. The Credit Increment MUST NOT
                    cause the window to overflow; if this condition
                    occurs, implementations MUST set the credit window
                    to the maximum value contained in a 64-bit
                    quantity.

9.22 Credit Request

The Credit Request TLV is an OPTIONAL TLV. If credits are supported,
the Credit Request TLV MAY be sent from either DLEP participant, via
a Destination Update signal, to indicate the desire for the partner
to grant additional credits in order for data transfer to proceed on
the session. If the corresponding Destination Up message for this
session did NOT contain a Credit Window Status TLV, indicating that
credits are to be used on the session, then the Credit Request TLV
MUST be rejected by the receiver via a Destination Update ACK
message.

The Credit Request TLV contains the following fields:

```
 0                   1                   2
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |TLV Type =TBD  |Length = 0     | Reserved, MUST|
 |               |               | be set to 0   |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

TLV Type   - TBD

     Length   - 0

     Reserved   - This field is currently unused and MUST be set to 0.

[10]. DLEP Protocol Messages

   DLEP messages are encoded as a string of Type-Length-Value (TLV)
   constructs. The first TLV in a DLEP message MUST be a valid DLEP
   signal, as defined in [section 11.1] of this document. The second TLV
   MUST be the Identification data item, defined in [section 10.1]
   Following those two TLVs are 0 or more TLVs, representing the data
   items that are appropriate for the signal. The layout of a DLEP
   message is thus:

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| DLEP Signal   |DLEP Message   |Identification |Identification |
| Type value    |length (9 +    |TLV Type       |TLV length     |
| (value TBD)   |optional TLVs) |(TBD)          |(8)            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                          Router ID                            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                          Modem ID                             |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Start of optional DLEP        |
| TLVs...                       |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

   All DLEP messages (signals) begin with this structure. Therefore, in
   the following descriptions of specific messages, this header
   structure is assumed, and will not be replicated.

[10.1] Signal TLV Values

   As mentioned above, all DLEP messages begin with the Type value of
   the appropriate DLEP signal. Valid DLEP signals are:

```
        TLV       TLV
        Value     Description
        =====================================
        TBD       Peer Discovery
        TBD       Peer Offer
        TBD       Peer Initialization
        TBD       Peer Update
        TBD       Peer Update ACK
```

```
            TBD       Peer Termination
            TBD       Peer Termination ACK
            TBD       Destination Up
            TBD       Destination Up ACK
            TBD       Destination Down
            TBD       Destination Down ACK
            TBD       Destination Update
            TBD       Heartbeat
            TBD       Link Characteristics Request
            TBD       Link Characteristics ACK
```

10.2 Peer Discovery Message

The Peer Discovery Message is sent by a modem to discover DLEP
routers in the network. The Peer Offer message is required to
complete the discovery process. Implementations MAY implement their
own retry heuristics in cases where it is determined the Peer
Discovery Message has timed out.

Given the packet format described in section 11, the initial TLV Type
value is set to DLEP_PEER_DISCOVERY (value TBD).

There are NO Data Item TLVs associated with the Peer Discovery
message.

10.3 Peer Offer Message

The Peer Offer Message is sent by a DLEP router in response to a Peer
Discovery Message. Upon receipt, and processing, of a Peer Offer
message, the modem responds by issuing a TCP connect to the
address/port combination specified in the received Peer Offer.

The Peer Offer message MUST be sent to the unicast address of the
originator of Peer Discovery.

To construct a Peer Offer message, the initial TLV type value is set
to DLEP_PEER_OFFER (value TBD). The signal TLV is then followed by
all MANDATORY Data Item TLVs, then by any OPTIONAL Data Item TLVs the
implementation supports:

Mandatory Data Item TLVs:
            - DLEP Version
            - Heartbeat Interval
            - At least one (1) IPv4 or IPv6 Address TLV
            - DLEP Port

Optional Data Item TLVs:
            - Peer Type

                - Status

[10.4](#) Peer Initialization Message

   The Peer Initialization message is sent by a modem to start the DLEP
   TCP session. It is sent by the modem after a TCP connect to the
   address/port combination in a received Peer Offer, or to an
   address/port obtained from a-priori configuration.

   All supported metric data items MUST be included in the Peer
   Initialization message, with default values to be used on a "modem-
   wide" basis. This can be viewed as the modem "declaring" all
   supported metrics at DLEP session initialization. Receipt of any DLEP
   message containing a metric data item NOT included in Peer
   Initialization MUST be treated as an error, resulting in termination
   of the DLEP session between router and modem.

   To construct a Peer Initialization message, the initial TLV type
   value is set to DLEP_PEER_INIT (value TBD). The signal TLV is then
   followed by the required data items:

   Mandatory Data Item TLVs:
                - DLEP Version
                - Heartbeat Interval
                - Maximum Data Rate Receive
                - Maximum Data Rate Transmit
                - Current Data Rate Receive
                - Current Data Rate Transmit
                - Latency
                - Relative Link Quality Receive
                - Relative Link Quality Transmit
   Optional Data Item TLVs:
                - Peer Type
   Note that metric data items MUST be supplied with the Peer
   Initialization, in order to populate default metric values. If, at
   any time, metrics are reported that were NOT in Peer Initialization,
   the receiving DLEP peer MUST treat this as a fatal error requiring
   termination of the DLEP session.

[10.5](#) Peer Initialization ACK Message

   The Peer Initialization ACK message is a MANDATORY message, sent in
   response to a received Peer Initialization message. The Peer
   Initialization ACK message completes the TCP-level DLEP session
   establishment; the sender of the message should transition to an "in-
   session" state when the message is sent, and the receiver should
   transition to the "in-session" state upon receipt (and successful
   parsing) of Peer Initialization ACK.

To construct a Peer Initialization ACK message, the initial TLV type
value is set to DLEP_PEER_INIT_ACK (value TBD). The signal TLV is
then followed by the required data items:

Mandatory Data Item TLVs:
            - Status
Optional Data Item TLVs:
            - Peer Type

10.6 Peer Update Message

The Peer Update message is an OPTIONAL message, sent by a DLEP peer
to indicate local Layer 3 address changes, or for metric changes on a
modem-wide basis. For example, addition of an IPv4 address to the
router MAY prompt a Peer Update message to its attached DLEP modems.
Also, a modem that changes its Maximum Data Rate for all destinations
MAY reflect that change via a Peer Update Message to its attached
router(s).

Concerning Layer 3 addresses, if the modem is capable of
understanding and forwarding this information (via proprietary
mechanisms), the address update would prompt any remote DLEP modems
(DLEP-enabled modems in a remote node) to issue a "Destination
Update" message to their local routers with the new (or deleted)
addresses. Modems that do not track Layer 3 addresses SHOULD silently
parse and ignore the Peer Update Message. Modems that track Layer 3
addresses MUST acknowledge the Peer Update with a Peer Update ACK
message. Routers receiving a Peer Update with metric changes MUST
apply the new metric to all destinations (remote nodes) accessible
via the modem. Supporting implementations are free to employ
heuristics to retransmit Peer Update messages. The sending of Peer
Update Messages for Layer 3 address changes SHOULD cease when a
either participant (router or modem) determines that the other
implementation does NOT support Layer 3 address tracking.

If metrics are supplied with the Peer Update message (e.g. Maximum
Data Rate), these metrics are considered to be modem-wide, and
therefore MUST be applied to all destinations in the information base
associated with the router/modem session.

To construct a Peer Update message, the initial TLV type value is set
to DLEP_PEER_UPDATE (value TBD). The Signal TLV is followed by any
OPTIONAL Data Item TLVs.

Optional Data Item TLVs:
            - IPv4 Address
            - IPv6 Address
            - Maximum Data Rate (Receive)

                    - Maximum Data Rate (Transmit)
                    - Current Data Rate (Receive)
                    - Current Data Rate (Transmit)
                    - Latency
                    - Expected Forwarding Time
                    - Resources (Receive)
                    - Resources (Transmit)
                    - Relative Link Quality (Receive)
               - Relative Link Quality (Transmit)

[10.7](#) **Peer Update ACK Message**

   The Peer Update ACK message is an OPTIONAL message, and is sent by
   implementations supporting Layer 3 address tracking and/or modem-wide
   metrics to indicate whether a Peer Update Message was successfully
   processed. If the Peer Update ACK is issued, it MUST contain a Status
   data item, indicating the success or failure of processing the
   received Peer Update.

   To construct a Peer Update ACK message, the initial TLV type value is
   set to DLEP_PEER_UPDATE_ACK (value TBD). The Status data item TLV is
   placed in the packet next, completing the Peer Update ACK.

   Mandatory Data Item TLVs:

           - Status

   Note that there are NO OPTIONAL data item TLVs specified for this
   message.

[10.8](#) **Peer Termination Message**

   The Peer Termination Message is sent by a DLEP participant when the
   router/modem session needs to be terminated. Implementations
   receiving a Peer Termination message MUST send a Peer Termination ACK
   message to confirm the termination process. The sender of a Peer
   Termination message is free to define its heuristics in event of a
   timeout. The receiver of a Peer Termination Message MUST release all
   resources allocated for the router/modem session, and MUST eliminate
   all destinations in the information base accessible via the
   router/modem pair represented by the session. Router and modem state
   machines are returned to the "discovery" state. No Destination Down
   messages are sent.

   To construct a Peer Termination message, the initial TLV type value
   is set to DLEP_PEER_TERMINATION (value TBD). The Signal TLV is
   followed by any OPTIONAL Data Item TLVs the implementation supports:

Optional Data Item TLVs:

        - Status

[10.9](#) Peer Termination ACK Message

The Peer Termination Message ACK is sent by a DLEP peer in response
to a received Peer Termination order. Receipt of a Peer Termination
ACK message completes the teardown of the router/modem session.

To construct a Peer Termination ACK message, the initial TLV type
value is set to DLEP_PEER_TERMINATION_ACK (value TBD). The
Identification data item TLV is placed in the packet next, followed
by any OPTIONAL TLVs the implementation supports:

Optional Data Item TLVs:

        - Status

[10.10](#) Destination Up Message

A DLEP participant sends the Destination Up message to report that a
new destination has been detected. A Destination Up ACK Message is
required to confirm a received Destination Up. A Destination Up
message can be sent either by the modem, to indicate that a new
remote node has been detected, or by the router, to indicate the
presence of a new logical destination (e.g., a Multicast group)
exists in the network.

The sender of the Destination Up Message is free to define its retry
heuristics in event of a timeout. When a Destination Up message is
received and successfully parsed, the receiver should add knowledge
of the new destination to its information base, indicating that the
destination is accessible via the modem/router pair.

To construct a Destination Up message, the initial TLV type value is
set to DLEP_Destination_UP (value TBD). The MAC Address data item TLV
is placed in the packet next, followed by any supported OPTIONAL Data
Item TLVs into the packet:

Optional Data Item TLVs:

        - IPv4 Address
        - IPv6 Address
        - Maximum Data Rate (Receive)
        - Maximum Data Rate (Transmit)
        - Current Data Rate (Receive)
        - Current Data Rate (Transmit)

                        - Latency
                        - Expected Forwarding Time
                        - Resources (Receive)
                        - Resources (Transmit)
                        - Relative Link Factor (Receive)
                        - Relative Link Factor (Transmit)
                        - Credit Window Status

[10.11](#) Destination Up ACK Message

   A DLEP participant sends the Destination Up ACK Message to indicate
   whether a Destination Up Message was successfully processed.

   To construct a Destination Up ACK message, the initial TLV type value
   is set to DLEP_Destination_UP_ACK (value TBD). The MAC Address data
   item TLV is placed in the packet next, containing the MAC address of
   the DLEP destination. The implementation would then place any
   supported OPTIONAL Data Item TLVs into the packet:

   Optional Data Item TLVs:
                - Credit Window Status

[10.12](#) Destination Down Message

   A DLEP peer sends the Destination Down message to report when a
   destination (a remote node or a multicast group) is no longer
   reachable. The Destination Down message MUST contain the MAC Address
   data item TLV. Other TLVs as listed are OPTIONAL, and MAY be present
   if an implementation supports them. A Destination Down ACK Message
   MUST be sent by the recipient of a Destination Down message to
   confirm that the relevant data has been removed from the information
   base. The sender of the Destination Down message is free to define
   its retry heuristics in event of a timeout.

   To construct a Destination Down message, the initial TLV type value
   is set to DLEP_Destination_DOWN (value TBD). The signal TLV is
   followed by the mandatory MAC Address data item TLV.

   Note that there are NO OPTIONAL data item TLVs for this message.

[10.13](#) Destination Down ACK Message

   A DLEP participant sends the Destination Down ACK Message to indicate
   whether a received Destination Down Message was successfully
   processed. If successfully processed, the sender of the ACK MUST have
   removed all entries in the information base that pertain to the
   referenced destination. As with the Destination Down message, there
   are NO OPTIONAL Data Item TLVs defined for the Destination Down ACK

message.

To construct a Destination Down message, the initial TLV type value
is set to DLEP_Destination_DOWN_ACK (value TBD). The mandatory data
item TLVs follow:

   - MAC Address Data item
   - Status data item

10.14 Destination Update Message

A DLEP participant sends the Destination Update message when it
detects some change in the information base for a given destination
(remote node or multicast group). Some examples of changes that would
prompt a Destination Update message are:

   - Change in link metrics (e.g., Data Rates)
   - Layer 3 addressing change (for implementations that support it)

To construct a Destination Update message, the initial TLV type value
is set to DLEP_Destination_UPDATE (value TBD). Following the signal
TLV are the mandatory Data Item TLVs:

MAC Address data item TLV

After placing the mandatory data item TLV into the packet, the
implementation would place any supported OPTIONAL data item TLVs.
Possible OPTIONAL data item TLVs are:

            - IPv4 Address
            - IPv6 Address
            - Maximum Data Rate (Receive)
            - Maximum Data Rate (Transmit)
            - Current Data Rate (Receive)
            - Current Data Rate (Transmit)
            - Latency
            - Resources (Receive)
            - Resources (Transmit)
            - Relative Link Quality (Receive)
            - Relative Link Quality (Transmit)
            - Credit Window Status
            - Credit Grant
            - Credit Request

10.15 Heartbeat Message

A Heartbeat Message is sent by a DLEP participant every N seconds,
where N is defined in the "Heartbeat Interval" field of the discovery
message. Note that implementations setting the Heartbeat Interval to
0 effectively set the interval to an infinite value, therefore, in
those cases, this message would NOT be sent.

The message is used by participants to detect when a DLEP session
partner (either the modem or the router) is no longer communicating.
Participants SHOULD allow two (2) heartbeat intervals to expire with
no traffic on the router/modem session before initiating DLEP session
termination procedures.

To construct a Heartbeat message, the initial TLV type value is set
to DLEP_PEER_HEARTBEAT (value TBD). The signal TLV is followed by the
mandatory Heartbeat Interval/Threshold data item.

Note that there are NO OPTIONAL data item TLVs for this message.

10.16 Link Characteristics Request Message

The Link Characteristics Request Message is an OPTIONAL message, and
is sent by the router to request that the modem initiate changes for
specific characteristics of the link. The request can reference
either a real (e.g., a remote node), or a logical (e.g., a multicast
group) destination within the network.

The Link Characteristics Request message contains either a Current
Data Rate (CDRR or CDRT) TLV to request a different datarate than
what is currently allocated, a Latency TLV to request that traffic
delay on the link not exceed the specified value, or both. A Link
Characteristics ACK Message is required to complete the request.
Implementations are free to define their retry heuristics in event of
a timeout. Issuing a Link Characteristics Request with ONLY the MAC
Address TLV is a mechanism a peer MAY use to request metrics (via the
Link Characteristics ACK) from its partner.

To construct a Link Characteristics Request message, the initial TLV
type value is set to DLEP_Destination_LINK_CHAR_REQ (value TBD).
Following the signal TLV is the mandatory Data Item TLV:

MAC Address data item TLV

After placing the mandatory data item TLV into the packet, the
implementation would place any supported OPTIONAL data item TLVs.
Possible OPTIONAL data item TLVs are:

Current Data Rate - If present, this value represents the NEW (or

                              unchanged, if the request is denied) Current
                              Data Rate in bits per second (bps).

      Latency   -   If present, this value represents the maximum
                              desired latency (e.g., it is a not-to-exceed
                              value) in milliseconds on the link.

[10.17](#) Link Characteristics ACK Message

   The LInk Characteristics ACK message is an OPTIONAL message, and is
   sent by modems supporting it to the router letting the router know
   the success or failure of a requested change in link characteristics.
    The Link Characteristics ACK message SHOULD contain a complete set
   of metric data item TLVs. It MUST contain the same TLV types as the
   request. The values in the metric data item TLVs in the Link
   Characteristics ACK message MUST reflect the link characteristics
   after the request has been processed.

   To construct a Link Characteristics Request ACK message, the initial
   TLV type value is set to DLEP_Destination_LINK_CHAR_ACK (value TBD).
   Following the signal TLV is the mandatory Data Item TLV:

   MAC Address data item TLV

   After placing the mandatory data item TLV into the packet, the
   implementation would place any supported OPTIONAL data item TLVs.
   Possible OPTIONAL data item TLVs are:

   Current Data Rate - If present, this value represents the requested
                         data rate in bits per second (bps).

   Latency   - If present, this value represents the NEW
                          maximum latency (or unchanged, if the request
                          is denied), expressed in milliseconds, on the
                          link.

[11](#). Security Considerations

   The protocol does not contain any mechanisms for security (e.g.
   authentication or encryption). The protocol assumes that any security
   would be implemented in the underlying transport (for example, by use
   of DTLS or some other mechanism), and is therefore outside the scope
   of this document.

[12](#). IANA Considerations

   This section specifies requests to IANA.

12.1 Registrations

This specification defines:

o A new repository for DLEP signals, with fifteen values currently
assigned.

o Reservation of numbering space for Experimental DLEP signals.

o A new repository for DLEP Data Items, with twenty-one values
currently assigned.

o Reservation of numbering space in the Data Items repository for
experimental data items.

o A request for allocation of a well-known port for DLEP
communication.

o A request for allocation of a multicast address for DLEP
discovery.

12.2 Expert Review: Evaluation Guidelines

No additional guidelines for expert review are anticipated.

12.3 Message (Signal) TLV Type Registration

A new repository must be created with the values of the DLEP
messages. Valid signals are:

    o   Peer Discovery
    o   Peer Offer
    o   Peer Initialization
    o   Peer Initialization ACK
    o   Peer Update
    o   Peer Update ACK
    o   Peer Termination
    o   Peer Termination ACK
    o   Destination Up
    o   Destination Up ACK
    o   Destination Down
    o   Destination Down ACK
    o   Destination Update
    o   Heartbeat
    o   Link Characteristics Request
    o   Link Characteristics ACK

It is also requested that the repository contain space for
experimental signal types.

12.4 **DLEP Data Item Registrations**

A new repository for DLEP Data Items must be created. Valid Data
Items are:

  o   DLEP Version
  o   Peer Type
  o   MAC Address
  o   IPv4 Address
  o   IPv6 Address
  o   Maximum Data Rate (Receive)
  o   Maximum Data Rate (Transmit)
  o   Current Data Rate (Receive)
  o   Current Data Rate (Transmit)
  o   Latency
  o   Expected Forwarding Time
  o   Resources (Receive)
  o   Resources (Transmit)
  o   Relative Link Quality (Receive)
  o   Relative Link Quality (Transmit)
  o   Status
  o   Heartbeat Interval/Threshold
  o   Link Characteristics ACK Timer
  o   Credit Window Status
  o   Credit Grant
  o   Credit Request

It is also requested that the registry allocation contain space for
experimental data items.

12.5 **DLEP Well-known Port**

It is requested that IANA allocate a well-known port number for DLEP
communication.

12.6 **DLEP Multicast Address**

It is requested that IANA allocate a multicast address for DLEP
discovery messages.

13. **Appendix A**.

13.1 **Peer Level Message Flows**

13.1.1 Modem Device Restarts Discovery

```
   Router                      Modem   Message Description
   ================================================================

   <-------Peer Discovery---------     Modem initiates discovery


    ---------Peer Offer----------->    Router detects a problem, sends
      w/ Non-zero Status TLV           Peer Offer w/Status TLV indicating
                                       the error.

                                       Modem accepts failure, restarts
                                       discovery process.

   <-------Peer Discovery---------     Modem initiates discovery


    ---------Peer Offer----------->    Router accepts, sends Peer Offer
         w/ Zero Status TLV            w/ Status TLV indicating success.

                                       Discovery completed.
```

13.1.2 Modem Device Detects Peer Offer Timeout

```
   Router                      Modem   Message Description
   ================================================================

   <-------Peer Discovery---------     Modem initiates discovery, starts
                                        a guard timer.

                                       Modem guard timer expires. Modem
                                       restarts discovery process.

    <-------Peer Discovery---------    Modem initiates discovery, starts
                                        a guard timer.

    ---------Peer Offer----------->    Router accepts, sends Peer Offer
         w/ Zero Status TLV            w/ Status TLV indicating success.

                                       Discovery completed.
```

13.1.3 Router Peer Offer Lost

```
Router                      Modem    Message Description
==================================================================

<-------Peer Discovery---------     Modem initiates discovery, starts
                                    a guard timer.

  ---------Peer Offer-------||      Router offers availability

                                    Modem times out on Peer Offer,
                                    restarts discovery process.

<-------Peer Discovery---------     Modem initiates discovery

  ---------Peer Offer----------->   Router detects subsequent
                                    discovery, internally terminates
                                    the previous, accepts the new
                                    association, sends Peer Offer
                                    w/Status TLV indicating success.


                                    Discovery completed.
```

13.1.4 Discovery Success

```
Router                      Modem    Message Description
==================================================================

<-------Peer Discovery---------     Modem initiates discovery

  ---------Peer Offer----------->   Router offers availability

 <-----Peer Initialization------     Modem Connects on TCP Port

 <------Peer Heartbeat----------

-------Peer Heartbeat--------->

<============================>   Message flow about destinations
                                    (i.e. Destination Up, Destination
                                 Down, Destination update)

<-------Peer Heartbeat---------

  -------Peer Heartbeat--------->
```

```
    --------Peer Term Req--------->   Terminate Request

   <--------Peer Term Res---------    Terminate Response
```

[29.1.5](#) Router Detects a Heartbeat timeout

```
   Router                    Modem   Message Description
   ==================================================================

   <-------Peer Heartbeat---------

    -------Peer Heartbeat--------->

      ||---Peer Heartbeat---------

          ~ ~ ~ ~ ~ ~ ~

    -------Peer Heartbeat--------->

      ||---Peer Heartbeat---------
                                     Router Heartbeat Timer expires,
                                     detects missing heartbeats. Router
                                     takes down all destination sessions
                                     and terminates the Peer
                                     association.

    ------Peer Terminate --------->   Peer Terminate Request

                                     Modem takes down all destination
                                     sessions, then acknowledges the
                                     Peer Terminate

   <----Peer Terminate ACK---------   Peer Terminate ACK
```

[29.1.6](#) Modem Detects a Heartbeat timeout

```
   Router                    Modem   Message Description
   ==================================================================

   <-------Peer Heartbeat---------

    -------Peer Heartbeat------||

   <-------Peer Heartbeat---------

          ~ ~ ~ ~ ~ ~ ~

    -------Peer Heartbeat------||
```

```
   <-------Peer Heartbeat---------
                                   Modem Heartbeat Timer expires,
                                   detects missing heartbeats. Modem
                                   takes down all destination sessions

    <-------Peer Terminate--------    Peer Terminate Request

                                      Router takes down all destination
                                      sessions, then acknowledges the
                                      Peer Terminate

    ------Peer Terminate ACK----->    Peer Terminate ACK
```

29.1.7 Peer Terminate (from Modem) Lost

```
   Router                    Modem    Message Description
   ===================================================================

    ||------Peer Terminate--------    Modem Peer Terminate Request

                                      Router Heartbeat times out,
                                      terminates association.

    --------Peer Terminate------->    Router Peer Terminate

    <-----Peer Terminate ACK------    Modem sends Peer Terminate ACK
```

29.1.8 Peer Terminate (from Router) Lost

```
   Router                    Modem    Message Description
   ===================================================================

    -------Peer Terminate-------->    Router Peer Terminate Request

                                      Modem HB times out,
                                      terminates association.

    <------Peer Terminate--------     Modem Peer Terminate

    ------Peer Terminate ACK----->    Peer Terminate ACK
```

29.2 Destination Specific Message Flows

29.2.1 **Modem Destination Up Lost**

```
   Router                      Modem    Message Description
   ====================================================================

    ||-----Destination Up ------------   Modem sends Destination Up

                                         Modem timesout on ACK

    <------Destination Up ------------   Modem sends Destination Up

     ------Destination Up ACK--------->  Router accepts the destination
                                         session

    <------Destination Update---------   Modem Destination Metrics
          . . . . . . .
    <------Destination Update---------   Modem Destination Metrics
```

29.2.2 **Router Detects Duplicate Destination Ups**

```
   Router                      Modem    Message Description
   ====================================================================

    <------Destination Up ------------   Modem sends Destination Up

     ------Destination Up ACK-------||   Router accepts the destination
                                         session

                                         Modem timesout on ACK

    <------Destination Up ------------   Modem resends Destination Up

                                         Router detects duplicate
                                         Destination, takes down the
                                         previous, accepts the new
                                         Destination.

     ------Destination Up ACK--------->  Router accepts the destination
                                         session

    <------Destination Update---------   Modem Destination Metrics
          . . . . . . .
    <------Destination Update---------   Modem Destination Metrics
```

29.2.3 Destination Up, No Layer 3 Addresses

```
Router                     Modem    Message Description
======================================================================

 <------Destination Up ------------   Modem sends Destination Up

  ------Destination Up ACK--------->   Router accepts the destination
                                       session

                                       Router ARPs for IPv4 if defined.
                                       Router drives ND for IPv6 if
                                       defined.

 <------Destination Update---------    Modem Destination Metrics
        . . . . . . .
 <------Destination Update---------    Modem Destination Metrics
```

29.2.4 Destination Up with IPv4, No IPv6

```
Router                     Modem    Message Description
===================================================================

 <------Destination Up ------------   Modem sends Destination Up with
                                      the IPv4 TLV

  ------Destination Up ACK--------->   Router accepts the destination
                                       session

                                       Router drives ND for IPv6 if
                                       defined.

 <------Destination Update---------    Modem Destination Metrics
        . . . . . . .
 <------Destination Update---------    Modem Destination Metrics
```

29.2.5 Destination Up with IPv4 and IPv6

```
Router                     Modem    Message Description
===================================================================

 <------Destination Up ------------   Modem sends Destination Up with
                                      the IPv4 and IPv6 TLVs

  ------Destination Up ACK--------->   Router accepts the destination
                                       session
```

```
    <------Destination Update---------    Modem Destination Metrics
            . . . . . . . .
```

29.2.6 Destination Session Success

```
   Router                    Modem    Message Description
   ===================================================================


    ---------Peer Offer----------->   Router offers availability

    -------Peer Heartbeat--------->


    <------Destination Up -----------      Modem

     ------Destination Up ACK-------->     Router

    <------Destination Update---------     Modem
            . . . . . . . .
    <------Destination Update---------     Modem

                                     Modem initiates the terminate

    <------Destination Down ----------     Modem

     ------Destination Down ACK------->    Router


                                     or


                                     Router initiates the terminate

     ------Destination Down ---------->    Router

    <------Destination Down ACK-------     Modem
```

Normative References

   [RFC5578] Berry, B., Ed., "PPPoE with Credit Flow and Metrics",
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   [RFC2119] Bradner, S., "Key words for use in RFCs to Indicate

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