

## Dynamic Link Exchange Protocol (DLEP) Multi-Hop Forwarding Extension

### Abstract

This document defines an extension to the Dynamic Link Exchange Protocol (DLEP) that enables the reporting and control of multi-hop forwarding by DLEP-capable modems.

### Status of This Memo

This is an Internet Standards Track document.

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## 1. Introduction

The Dynamic Link Exchange Protocol (DLEP) is defined in [RFC8175]. It provides the exchange of link-related control information between a modem and a router. DLEP defines a base set of mechanisms as well as support for possible extensions. This document defines one such extension.

Some modem technologies support mobile ad hoc network (MANET) forwarding where connectivity to destinations is provided via forwarding in intermediate modems. This document refers to forwarding by intermediate modems as "multi-hop forwarding". DLEP Destination Messages can be used to report such reachable destinations (see [RFC8175]), but do not provide any information related to the number or capacity of the hops. The extension defined in this document enables modems to inform routers when multi-hop forwarding is being used and allows routers to request that modems change multi-hop forwarding behavior. The extension defined in this document is referred to as "Multi-Hop Forwarding", where each modem that transmits/sends data to reach a particular destination is counted as a hop.

It is important to note that the use of the Hop Control mechanism defined in this document can result in connectivity changes and even loss of the ability to reach one or more destinations. The defined

mechanism will report such connectivity changes, but the details of what a router does or how it reacts to such are out scope of this document.

This document defines a new DLEP Extension Type Value in [Section 2](#), which indicates the use of the extension, and three new DLEP Data Items in [Section 3](#).

### 1.1. Key Words

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "NOT RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in [BCP 14 \[RFC2119\] \[RFC8174\]](#) when, and only when, they appear in all capitals, as shown here.

## 2. Extension Usage and Identification

The use of the Multi-Hop Forwarding Extension SHOULD be configurable. Per [\[RFC8175\]](#), to indicate that the extension is to be used, an implementation includes the Multi-Hop Forwarding Extension Type Value in the Extensions Supported Data Item. The Extensions Supported Data Item is sent and processed according to [\[RFC8175\]](#).

The Multi-Hop Forwarding Extension Type Value is 1 (see [Section 5](#)).

## 3. Extension Data Items

Three data items are defined by this extension. The Hop Count Data Item is used by a modem to provide the number of modem hops traversed to reach a particular destination. The Hop Control Data Item is used by a router to request that a modem alter connectivity to a particular destination. The Suppress Forwarding Data Item is used by a router to request that a modem disable multi-hop forwarding on either a device or destination basis.

### 3.1. Hop Count

The Hop Count Data Item is used by a modem to indicate the number of modems that transmit/send data to reach a particular destination, i.e., hops, between the modem and a specific destination. In other words, each hop represents a transmission, and the number of hops is equal to the number of transmissions required to go from a router's connected modem to the destination's connected modem. The minimum number of hops is 1, which represents transmission to destinations that are directly reachable via the router's locally connected modem.

The data item also contains an indication of when a destination that currently has a hop count of greater than one (1) could be made directly reachable by a modem, e.g., by reaiming an antenna.

The Hop Count Data Item SHOULD be carried in the Destination Up, Destination Update, Destination Announce Response, and Link Characteristics Response Messages when the Hop Count to a destination is greater than one (1).

A router receiving a Hop Count Data Item can use this information in its forwarding and routing decisions, but specific use is out of scope of this document. When using this extension, the absence of the Hop Count Data Item MUST be interpreted by the router as a Hop Count value of one (1).

The format of the Hop Count Data Item is:

```

      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
+-----+-----+-----+-----+-----+-----+-----+-----+
| Data Item Type | Length |
+-----+-----+-----+-----+-----+-----+-----+-----+
| P | Reserved  | Hop Count |
+-----+-----+-----+-----+-----+-----+-----+

```

Data Item Type: 21

Length: 2

P:

The P-bit indicates that a destination is potentially directly reachable. When the P-bit is set, the router MAY request a direct link to the associated destination using the Hop Control Data Item described below. This field MUST be ignored when the value contained in the Hop Count field is one (1).

Reserved:

The Reserved field MUST be set to zero by the sender (a modem) and ignored by the receiver (a router).

Hop Count:

The Hop Count is an unsigned 8-bit integer indicating the number of modem hops required (i.e., number of times a packet will be transmitted) to reach the destination indicated in the message. The special value of 255 (0xFF) is used to indicate that the

number of hops is an unknown number greater than one (1). This field MUST contain a value of at least one (1) if the associated destination is reachable.

A value of zero (0) is used to indicate that the processing of a Hop Control action (see [Section 3.2](#)) has resulted in the destination no longer being reachable. A zero value MUST NOT be used in any message other than a Link Characteristics Response Message.

### 3.2. Hop Control

The Hop Control Data Item is used by a router to request a change in connectivity to a particular destination or to perform multi-hop processing on a device-wide basis. A router can request that a multi-hop-reachable destination be changed to a single-hop destination. A router can also indicate that the modem terminates a previous direct connectivity request to a particular destination.

The Hop Control Data Item MAY be carried in a Session Update Message sent by a router when the control applies to the whole device, or a Link Characteristics Request Message when the control applies to a particular destination.

A modem that receives the Hop Control Data Item in a Link Characteristics Request Message SHOULD take whatever actions are needed to make the change indicated by the data item for the associated destination Media Access Control (MAC) address. Once the change is made, fails, or is rejected, the modem MUST respond with a Link Characteristics Response Message containing an updated Hop Count Data Item. Note that other destinations can be impacted as a result of the change, and such changes are reported in Destination Down and Destination Update Messages. The modem MUST notify the router of each destination that is not identified in the Link Characteristics Response Message and is no longer reachable via a Destination Down Message. The modem MUST also notify the router of each impacted destination that is not identified in the Link Characteristics Response Message via a Destination Update Message.

Failures may occur for multiple reasons, for example, the transmission characteristics of the link don't support the one-hop connection at the time of the request. Requests can be rejected by local policy.

A modem that receives the Hop Control Data Item in a Session Update Message SHOULD take whatever actions are needed to make the change indicated by the data item for all known destinations. Once the change is made, fails, or is rejected, the modem MUST respond with a

Session Update Response Message with an appropriate Status Code. The destination-specific impact of processing a Hop Control Data Item in a Session Update Message is provided via Destination Down and Destination Update Messages. The modem MUST notify the router of each destination that is no longer reachable via a Destination Down Message. The modem MUST notify the router of any changes in Hop Counts via Destination Update Messages.

The format of the Hop Control Data Item is:

```

      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
+-----+-----+-----+-----+-----+-----+-----+-----+
| Data Item Type                               | Length                               |
+-----+-----+-----+-----+-----+-----+-----+-----+
|               Hop Control Actions               |
+-----+-----+-----+-----+-----+-----+

```

Data Item Type: 22

Length: 2

Hop Control Actions:

The Hop Control Actions field is an unsigned 16-bit value with the following meaning:

Value	Action
0	Reset
1	Terminate
2	Direct Connection
3	Suppress Forwarding

Table 1: Hop Control Actions Values

### 3.2.1. Reset

The Reset Action requests that the default behavior be restored. When received in a Session Update Message, a modem MUST clear all control actions that have previously been processed on a device-wide basis and revert to its configured behavior. When received in a Link Characteristics Request Message, a modem MUST clear all control actions that have previously been processed for the destination indicated in the message.

### 3.2.2. Terminate

The Terminate Action is only valid on a per-destination basis and MUST NOT be sent in a Session Update Message. It indicates that a direct connection is no longer needed with the destination identified in the message. This request has no impact on multi-hop destinations and may fail even in a single-hop case, i.e., it can result in the Hop Count to the destination not being impacted by the processing of the request.

### 3.2.3. Direct Connection

The Direct Connection Action is only valid on a per-destination basis and MUST NOT be sent in a Session Update Message. It indicates that the modem SHOULD attempt to establish a direct connection with the destination identified in the message. This action SHOULD only be sent for destinations for which the Hop Count is both greater than 1 and has the P-Bit set in the previously received Hop Count Data Item. Results of the request for the destination identified in the message are provided as described above.

### 3.2.4. Suppress Forwarding

The Suppress Forwarding Action is used by a router to indicate to its peer that multi-hop forwarding performed by the modem is to be suppressed. A router can request that multi-hop forwarding be suppressed on a device-wide or destination-specific basis.

A modem that receives the Suppress Forwarding Data Item in a Session Update Message MUST suppress multi-hop forwarding on a device-wide basis. This means that data traffic originating from the modem's peer router SHALL only be sent by the modem to destinations that are one modem hop away, and that any data traffic received by the modem from another modem that is not destined to the peer router SHALL be dropped. The impact on destination hop counts are provided to the router by the modem as described above.

A modem that receives the Suppress Forwarding Data Item in a Link Characteristics Request Message MUST suppress multi-hop forwarding for only the destination indicated in the message. This means that data traffic originating from the modem's peer router SHALL be sent by the modem to the destination indicated in the Link Characteristics Request Message only when it is one modem hop away. Notably, data traffic received by the modem from another modem can be forwarded by the modem per its normal processing. Results are provided as described above.

#### 4. Security Considerations

The extension defined in this document enables the reporting and control of forwarding information by DLEP-capable modems. The extension does not inherently introduce any additional vulnerabilities above those documented in [RFC8175]. The approach taken to security in that document applies equally when running the extension defined in this document.

The extension does define one mechanism that is worth particular note. It includes a Hop Control mechanism (see [Section 3.2](#)) that is similar to the Link Characteristics Request Message defined in [RFC8175] in that it can impact the set of destinations reported as reachable. With the Link Characteristics Request Message, this risk is implicit. With the Hop Control mechanism defined in this document, it is more likely. From a security perspective, implementations should be aware of this increased risk and may choose to implement additional configuration control mechanisms to ensure that the Hop Control mechanism is only used under conditions intended by the network operator.

Implementations of the extension defined in this document MUST support configuration of TLS usage, as described in [RFC8175], in order to protect configurations where injection attacks are possible, i.e., when the link between a modem and router is not otherwise protected.

Note that this extension does allow a compromised or impersonating modem to suppress transmission by the router or a switch that interconnects the modem and router. Similar attacks are generally possible for DLEP, for example, an impersonating modem may cause a session reset or cause a compromised modem to simply drop all traffic destined to, or sent by, a router. [RFC8175] defines the use of TLS to protect against the impersonating attacker.

#### 5. IANA Considerations

As described below, IANA has assigned 3 values to registries defined by [RFC8175] and created a new registry.

##### 5.1. Extension Type Value

IANA has registered the following new value in the Specification Required range of the "Extension Type Values" registry within the "Dynamic Link Exchange Protocol (DLEP) Parameters" registry.



Code	Description
1	Multi-Hop Forwarding

Table 2: Requested Extension Type Value

## 5.2. Data Item Values

IANA has registered the following 2 values in the Specification Required range of the "Data Item Type Values" registry within the "Dynamic Link Exchange Protocol (DLEP) Parameters" registry.

Type Code	Description
21	Hop Count
22	Hop Control

Table 3: Requested Data Item Values

## 5.3. Hop Control Actions Registry

IANA has created the "Hop Control Actions Values" registry within the "Dynamic Link Exchange Protocol (DLEP) Parameters" registry. The following table provides initial registry values and the registration procedures [RFC8126] that apply:

Value	Action/Policy
0	Reset
1	Terminate
2	Direct Connection
3	Suppress Forwarding
4-65519	Specification Required
65520-65534	Private Use
65535	Reserved

Table 4: Hop Control Actions Values

## 6. References

### 6.1. Normative References

- [RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", [BCP 14](#), [RFC 2119](#), DOI 10.17487/RFC2119, March 1997, <<https://www.rfc-editor.org/info/rfc2119>>.
- [RFC8174] Leiba, B., "Ambiguity of Uppercase vs Lowercase in [RFC 2119](#) Key Words", [BCP 14](#), [RFC 8174](#), DOI 10.17487/RFC8174, May 2017, <<https://www.rfc-editor.org/info/rfc8174>>.
- [RFC8175] Ratliff, S., Jury, S., Satterwhite, D., Taylor, R., and B. Berry, "Dynamic Link Exchange Protocol (DLEP)", [RFC 8175](#), DOI 10.17487/RFC8175, June 2017, <<https://www.rfc-editor.org/info/rfc8175>>.

### 6.2. Informative References

- [RFC8126] Cotton, M., Leiba, B., and T. Narten, "Guidelines for Writing an IANA Considerations Section in RFCs", [BCP 26](#), [RFC 8126](#), DOI 10.17487/RFC8126, June 2017, <<https://www.rfc-editor.org/info/rfc8126>>.

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