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Dynamic Link Exchange Protocol (DLEP) Credit-Based Flow Control Messages
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Abstract

This document defines new Dynamic Link Exchange Protocol (DLEP) Data Items that are used to support credit-based flow control. Credit window control is used to regulate when data may be sent to an associated virtual or physical queue. The Data Items are extensible and reusable.

Status of This Memo

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1. Introduction

The Dynamic Link Exchange Protocol (DLEP), defined in [RFC8175], provides the exchange of link related control information between DLEP peers. DLEP peers are comprised of a modem and a router. DLEP defines a base set of mechanisms as well as support for future extensions. DLEP defines Data Items which are sets of information that can be reused in DLEP messaging. The DLEP specification does not include any flow identification beyond DLEP endpoints nor flow control capability. There are various flow control techniques

theoretically possible with DLEP. For example, a credit-window scheme for destination-specific flow control which provides aggregate flow control for both modem and routers has been proposed in [I-D.ietf-manet-credit-window], and a control plane pause based mechanism is defined in [RFC8651]. The use of other flow control mechanisms simultaneously with Credit-Based Flow Control is not within the scope of this document.

Credit-Based Flow Control, as a result of its proactive nature, may offer some advantages over a pause mechanism. Packet loss resulting from insufficient buffer space is less likely, as a transmitter does not send packets until the receiver has indicated that there is sufficient buffer available.

Figure 1 illustrates a local node consisting of a router and a modem with a DLEP. DLEP messages optionally contain a number of Data Items and Sub-data Items. Traffic flow classification Data Items provided by the modem, are defined in [I-D.ietf-manet-dlep-traffic-classification]. In this case, a flow is identified based on information found in a data plane header and one or more matches are associated with a single flow. Refer to Section 2.3 of [RFC2475] for general background on traffic classification.

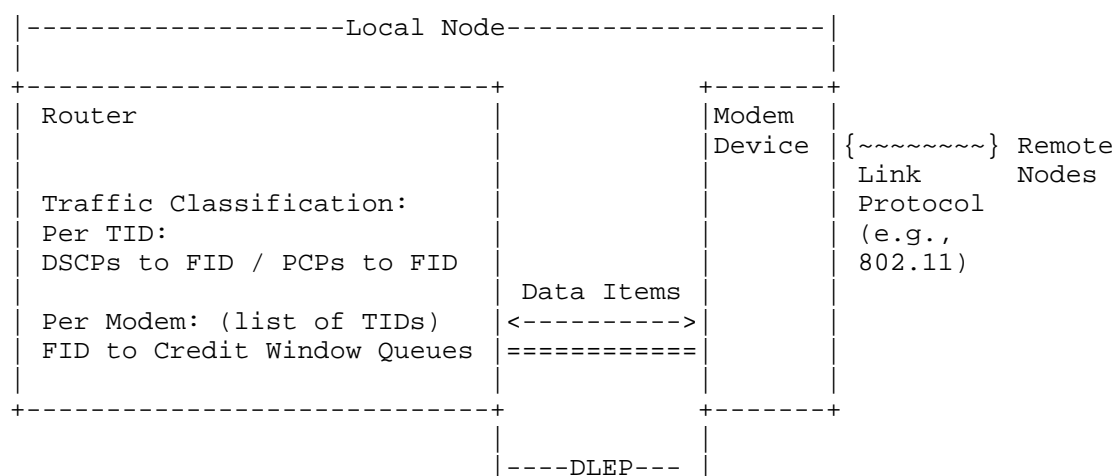


Figure 1: Router and Modem DLEP Exchange

This document defines DLEP Data Items which provide a flow control mechanism for traffic sent from a router to a modem. Flow control is provided using one or more logical "Credit Windows", each of which

will typically be supported by an associated virtual or physical queue. Credit windows may be shared or dedicated on a per flow basis. The Data Items are structured to allow for reuse of the defined credit window based flow control with different traffic classification techniques. A router logically consumes credits for each credit window matching packet sent.

Note that this document defines common Messages, Data Items and mechanisms that are reusable. They are expected to be required by DLEP extensions defined in other documents such as found in [I-D.ietf-manet-dlep-da-credit-extension].

This document introduces support for credit window control by defining two new DLEP messages in Section 2.2, and five new DLEP Data Items in Section 2.3.

Various conditions described in this document cause a message to be logged. In all cases, the log message results from the contents of a received Data Item defined here. No messages are logged in response to activity in the data plane.

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. Credit Window Control

This section defines additions to DLEP used in credit based flow control. The use of credit window control impacts the data plane.

The credit window control mechanisms defined in this document support credit based flow control of traffic sent from a router to a modem. The mapping of specific flows to a particular credit window is based on the Traffic Classification Data Item defined in [I-D.ietf-manet-dlep-traffic-classification]. Both types of DLEP peers, router and modem, negotiate the use of an extension employing this mechanism during session initialization as required, for example, by [I-D.ietf-manet-dlep-da-credit-extension]. When using credit windows, data traffic is only allowed to be sent by the router to the modem when there are credits available.

Credits are managed on a per logical "Credit Window" basis. Each credit window can be thought of as corresponding to a queue within a modem. Credit windows may be shared across, or dedicated to,

destinations and data plane identifiers, for example, DSCPs, at a granularity that is appropriate for a modem's implementation and its attached transmission technology. As defined below in Section 2.3.1, there is a direct one-for-one mapping of credit windows to flows as identified by Flow Identifiers (FIDs) carried within the Traffic Classification Data Item. Modems pass to the router information on their credit windows and FIDs prior to a router being able to send data when an extension requiring the use of credit window control is used. Note that TID and FID values are significant only to the issuing modem. There is no relationship implied by the same TID or FID value being issued by more than one modem. In addition to the traffic classification information associated with a FID, modems provide an initial credit window size, as well as the maximum size of the logical queue associated with each credit window. The maximum size is included for informative and potential future uses.

Modems provide an initial credit window size at the time of "Credit Window Initialization". Such initialization can take place during session initiation or any point thereafter. It can also take place when rate information changes. An increment to a Credit Window size, specified in a Credit Grant Data Item, is provided in a Destination Up or the new "Credit Control" Message. A router provides its view of the Credit Window, which is known as "Status", in Destination Up Response and the new "Credit Control Response" Messages. Routers can also request credits using the new "Credit Control" Message.

When modems provide credits to a router, they will need to take into account any overhead of their attached transmission technology and map it into the credit semantics defined in this document. In particular, the credit window is defined below to include per frame (packet) MAC headers, and this may not match the actual overhead of the modem attached transmission technology. In that case a direct mapping, or an approximation will need to be made by the modem to provide appropriate credit values.

Actual flows of traffic are mapped to credit windows based on flow identification information provided by modems in the Traffic Classification Data Item defined in [I-D.ietf-manet-dlep-traffic-classification]. This data item supports traffic classification on a per destination or more fine grain level. Routers use the combination of the DLEP identified destination and flow information associated with a credit window in order to match traffic they send to specific credit windows. In some cases, the Traffic Classification Data Item allows the modem to specify a wildcard to match any packets that do not match other data items, for example see [I-D.ietf-manet-dlep-ether-credit-extension]. In the absence of a wildcard, a packet may not match any of the data items and, in this case, MUST be dropped by the router.

When a destination becomes reachable, a modem "associates" (identifies) the appropriate traffic classification information via the Traffic Class Identifier (TID) to be used for traffic sent by the router to that destination. This is supported by the Credit Window Association Data Item which is carried in Destination Up and Update messages, see Section 2.3.2. The TID provides the information to support router traffic classification, based on the FIDs contained in the TID, see [I-D.ietf-manet-dlep-traffic-classification]. As defined, each credit window has a corresponding FID, so traffic is mapped to a credit window by locating a matching FID that is contained in the TID that is associated with the traffic's destination. This means that the use of FIDs, TIDs and the association of a TID to a DLEP destination enables a modem to share or dedicate resources as needed to match the specifics of its implementation and its attached transmission technology.

The defined credit window control has similar objectives as the control found in [I-D.ietf-manet-credit-window]. One notable difference from that credit control is that in this document, credits are never provided by the router to the modem.

2.1. Data Plane Considerations

When credit windowing is used, a router MUST NOT send data traffic to a modem for forwarding if there is no matching classifier. If a matching classifier is found, a router MUST NOT send data traffic to a modem when there are no credits available in the associated Credit Window. Section 2 describes how classifiers are associated with destinations and how credit windows are associated with classifiers. Additionally, a router MUST ensure sufficient credits are available in the associated Credit Window for the current data packet before sending that data packet to the modem. The count of octets in the packet includes MAC overhead. In the example of Ethernet, framing, header and trailer are all included in this count. This document defines credit windows in octets and the credit window is decremented by the number of sent octets.

A router MUST identify the credit window associated with traffic to be sent to a modem based on the traffic classification information provided in the Data Items defined in this document.

2.2. Credit Window Messages

Two new messages are defined in support for credit window control: the Credit Control and the Credit Control Response Messages. Sending and receiving both message types is REQUIRED to support the credit window control defined in this document.

2.2.1. Credit Control Message

Credit Control Messages are sent by modems and routers. Each sender is only permitted to have one message outstanding at one time. That is, a sender (either modem or router) **MUST NOT** send any subsequent Credit Control Message until a Credit Control Response Message is received from its peer.

Credit Control Messages are sent by modems to provide credit window increases. Modems send credit increases when there is transmission or local queue availability that exceeds the credit window value previously provided to the router. Modems will need to balance the load generated by sending and processing credit window increases against a router having data traffic available to send, but no credits available.

Credit Control Messages **MAY** be sent by routers to request credits and provide window status. Routers will need to balance the load generated by sending and processing credit window requests against having data traffic available to send, but no credits available.

The Message Type value in the DLEP Message Header is set to TBA2.

A Credit Control message sent by a modem, **MUST** contain one or more Credit Window Grant Data Items as defined in Section 2.3.3. A router receiving this message **MUST** respond with a Credit Control Response Message.

A Credit Control message sent by a router, **MUST** contain one or more Credit Window Request Data Items defined in Section 2.3.5 and **SHOULD** contain a Credit Window Status Data Item, defined in Section 2.3.4, corresponding to each credit window request. A modem receiving this message **MUST** respond with a Credit Control Response Message based on the received message and Data Item and the processing defined in Section 2.2.2, which will typically result in credit window increments being provided.

Specific processing associated with each Credit Data Item is provided in Section 2.3.

2.2.2. Credit Control Response Message

Credit Control Response Messages are sent by routers to report the current Credit Window for a destination. A Credit Control Response message sent by a router, **MUST** contain one or more Credit Window Status Data Items as defined below in Section 2.3.4. Specific receive processing associated with the Credit Window Status Data Item is provided in Section 2.3.4.

Credit Control Response Messages sent by modems MUST contain one or more Credit Window Grant Data Items. A Data Item for every Credit Window Request Data Item contained in the corresponding Credit Control Message received by the modem MUST be included. Each Credit Grant Data Item MAY provide zero or more additional credits based on the modem's transmission or local queue availability. Specific receive processing associated with each Grant Data Item is provided in Section 2.3.3.

The Message Type value in the DLEP Message Header is set to TBA3.

2.3. Credit Window Control Data Items

Five new Data Items are defined to support credit window control. The Credit Window Initialization Data Item is used by a modem to identify a credit window and set its size. The Credit Window Association Data Item is used by a modem to identify which traffic classification identifiers (flows) should be used when sending traffic to a particular DLEP identified destination. The Credit Window Grant Data Item is used by a modem to provide additional credits to a router. The Credit Window Request Data Item is used by a router to request additional credits. The Credit Window Status Data Item is used to advertise the sender's view of number of available credits for state synchronization purposes.

Any errors or inconsistencies encountered in parsing Data Items are handled in the same fashion as any other data item parsing error encountered in DLEP, see [RFC8175]. In particular, the node parsing the Data Item MUST terminate the session with a Status Data Item indicating Invalid Data.

2.3.1. Credit Window Initialization

The Credit Window Initialization Data Item is used by a modem to identify a credit window and set its size. In order to avoid errors caused by the use of undefined FIDs or uninitialized credit windows, this Data Item SHOULD be included in any Session Initialization Response Message that indicates support for any such extension. Updates to previously identified credit windows or new credit windows MAY be sent by a modem by including the Data Item in Session Update Messages. More than one data item MAY be included in a message to provide information on multiple credit windows.

The Credit Window Initialization Data Item identifies a credit window using a Flow Identifier, or FID. It also provides the size of the identified credit window. To be used, a FID must be defined within a Traffic Classification Data Item and the associated TID must be provided via a Credit Window Association Data Item.

Value	Scale

0	B - Bytes (Octets)
1	KB - Kilobytes (B/1024)
2	MB - Megabytes (KB/1024)
3	GB - Gigabytes (MB/1024)

Credit Window Max Size:

A 24-bit unsigned integer representing the maximum size, in the octet scale indicated by the Scale field, of the associated credit window.

A router that receives a Credit Window Initialization Data Item MUST ensure that the FID field value has been provided by the modem in a Traffic Classification Data Item carried in either the current or a previous message. If the FID cannot be found the router SHOULD log this information. The method of logging is left to the router implementation. Note that no traffic will be associated with the credit window in this case. After FID validation, the router MUST locate the credit window that is associated with the FID indicated in each received Data Item. If no associated credit window is found, the router MUST initialize a new credit window using the values carried in the Data Item. When an associated credit window is found, the router MUST update the credit window and associated data plane state using the values carried in the Data Item. If the resulting Credit Value results in the credit window exceeding the represented Credit Window Max Size, the Credit Window Max Size field value is used as the new credit window size.

It is worth noting, that such updates can result in a credit window size being reduced, for example, due to a transmission rate change on the modem. After sending the Session Update Message with one or more Credit Window Initialization Data Items that decrease the Credit Window Max Size, the modem SHOULD continue processing received packets that match the indicated FIDs, fit within the window for the unmodified Credit Window Max Size and arrive before the modem receives the corresponding Session Update Response Message. The modem SHOULD NOT issue additional credits for any affected FID until that FID's associated Window has drained to be less than the new Credit Window Max Size, regardless of when the corresponding Session Update Response Message is received.

the TID and its corresponding FIDs are updated as needed (per Section 2.1). If a router determines that a newly received Data Item results in credit windows with overlapping TIDs, the Data Item MUST be treated as an error as described above.

2.3.3. Credit Window Grant

The Credit Window Grant Data Item is used by a modem to provide credits to a router. One or more Credit Window Grant Data Items MAY be carried in the DLEP Destination Up, Destination Announce Response, Destination Update, Credit Control Messages, and Credit Control Response Messages. Multiple Credit Window Grant Data Items may be present in a single message. Each item grants credits to a different credit window and, therefor, references a different FID. In all message types, this Data Item provides an additional number of octets to be added to the indicated credit window. Credit windows are identified using FID values that have been previously been sent by the modem or are listed in a Credit Window Initialization Data Item carried in the same message as the Data Item.

The format of the Credit Window Grant 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 (12)																																			
Flow Identifier (FID)												Reserved																																			
Additional Credits																																															

Data Item Type:

Data Item Type (TBA6)

Length:

12

As specified in [RFC8175], Length is the number of octets in the Data Item. It MUST be equal to twelve (12). If it is some other value, the Data Item is corrupt so the message in which it appears cannot be reliably parsed and is ignored.

Flow Identifier (FID):

A two-octet flow identifier as defined by the Traffic Classification Data Item. The FID also uniquely indicates a credit window.

Reserved:

For the Credit Window Grant Data Item this reserved field is currently unused. It MUST set to all zeros for this version of the Data Item and it is currently ignored on reception. This allows for future extensions of the Data Item if needed.

Additional Credit:

A 64-bit unsigned integer representing the credits, in octets, to be added to the Credit Window. This value includes MAC headers as seen on the link between the modem and router. A value of zero indicates that no additional credits are being provided.

When receiving this Data Item, a router MUST identify the credit window indicated by the FID. If the FID is not known to the router, it SHOULD log this information and discard the Data Item. The method of logging is left to the router implementation. It is important to note that while this Data Item can be received in a destination specific message, credit windows are managed independently from the destination identified in the message carrying this Data Item, and the indicated FID MAY even be disjoint from the identified destination.

Once the credit window is identified, the credit window size MUST be increased by the value contained in the Additional Credits field. If the increase results in a window overflow, the Credit Window must be set to its maximum as defined by the Credit Window Max Size carried in the Credit Window Initialization Data Item.

No response is sent by the router to a modem after processing a Credit Window Grant Data Item received in a Credit Control Response Message. When a Credit Window Grant Data Item is received in other message types, the receiving router MUST send a Credit Window Status Data Item or items reflecting the resulting Credit Window value of the updated credit window. When the Credit Grant Data Item is received in a Destination Up Message, the Credit Window Status Data Item(s) MUST be sent in the corresponding Destination Up Response Message. Otherwise, a Credit Control Message MUST be sent.

2.3.4. Credit Window Status

The Credit Window Status Data Item is used by a router to report the current credit window size to its peer modem. One or more Credit Window Status Data Items MAY be carried in a Destination Up Response Message or a Credit Control Response Message. As discussed in Section 2.3.3, the Destination Up Response Message is used when the Data Item is sent in response to a Destination Up Message, and the Credit Control Response Message is sent in response to a Credit Control Message. Multiple Credit Window Status Data Items in a

single message are used to indicate different sizes of different credit windows. Similar to the Credit Window Grant, credit windows are identified using FID values that have been previously been sent by the modem.

The format of the Credit Window Status 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 (12)          |
+-----+-----+-----+-----+-----+-----+-----+-----+
| Flow Identifier (FID)                         | Reserved                |
+-----+-----+-----+-----+-----+-----+-----+-----+
|                               Current Credit Window Size                               |
|-----|-----|-----|-----|-----|-----|-----|-----|
+-----+-----+-----+-----+-----+-----+-----+-----+

```

Data Item Type:

Data Item Type (TBA7)

Length:

12

As specified in [RFC8175], Length is the number of octets in the Data Item. It MUST be equal to twelve (12). If it is some other value, the Data Item is corrupt so the message in which it appears cannot be reliably parsed and is ignored.

Flow Identifier (FID):

A two-octet flow identifier as defined by the Traffic Classification Data Item. The FID also uniquely identifies a credit window.

Reserved:

For the Credit Window Status Data Item this reserved field is currently unused. It MUST set to all zeros for this version of the Data Item and it is currently ignored on reception. This allows for future extensions of the Data Item if needed.

Current Credit Window Size:

A 64-bit unsigned integer, indicating the current number of credits, in octets, available for the router to send to the modem. This is referred to as the Modem Receive Window in [I-D.ietf-manet-credit-window].

When receiving this Data Item, a modem MUST identify the credit window indicated by the FID. If the FID is not known to the modem, it SHOULD log this information and discard the Data Item. The method of logging is left to the modem implementation. As with the Credit Window Grant Data Item, the FID MAY be unrelated to the Destination indicated in the message carrying the Data Item.

Once the credit window is identified, the modem SHOULD check the received Current Credit Window Size field value against the outstanding credit window's available credits at the time the most recent Credit Window Initialization or Grant Data Item associated with the indicated FID was sent. If the difference in values is greater than can be accounted for based on observed data frames, then the modem SHOULD send a Credit Window Initialization Data Item to reset the associated credit window size to the modem's current view of the available credits. As defined in Section 2.3.1, Credit Window Initialization Data Items are sent in Session Update Messages. When multiple Data Items need to be sent, they SHOULD be combined into a single message when possible. Alternatively, and also in cases where there are small differences, the modem MAY adjust the values sent in Credit Window Grant Data Items to account for the reported Credit Window.

2.3.5. Credit Window Request

The Credit Window Request Data Item is used by a router to request additional credits for particular credit windows. Credit Window Request Data Items are carried in Credit Control Messages, and one or more Credit Window Request Data Items MAY be present in a message.

Credit windows are identified using a FID as defined in Section 2.3.1. Multiple FIDs MAY be present to allow for the case where the router identifies that credits are needed in multiple credit windows. A special FID value, as defined below, is used to indicate that a credit request is being made across all queues.

The format of the Credit Window Request 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	2	3	4	5	6	7	8	9
Data Item Type										Length																													
Flow Identifier (FID) [1]										Flow Identifier (FID) [2]																													
...										Flow Identifier (FID) [n]																													

Data Item Type:

Data Item Type (TBA8)

Length:

Variable

As specified in [RFC8175], Length is the number of octets in the Data Item, excluding the Type and Length fields. It is equal to the number of FID fields carried in the Data Item times 2 and MUST be at least 2. If it is less than 2, the Data Item is corrupt so the message in which it appears cannot be reliably parsed and is ignored.

Flow Identifier (FID):

A two-octet flow identifier as defined by the Traffic Classification Data Item. The FID also uniquely identifies a credit window. The special value of 0xFFFF indicates that the request applies to all FIDs. When this special value is included, all other FID values included in the Data Item are redundant as the special value indicates all FIDs.

A modem receiving this Data Item MUST provide a Credit Increment for the indicated credit windows via Credit Window Grant Data Items carried in a new Credit Control Message. Multiple values and queue indexes SHOULD be combined into a single Credit Control Message when possible. Unknown FID values SHOULD be logged and then ignored by the modem. The method of logging is left to the modem implementation.

2.4. Management Considerations

This section provides several network management guidelines to implementations supporting the credit window mechanisms defined in this document.

Modems MAY support the configuration of the number of credit windows (queues) to advertise to a router.

Routers may have limits on the number of queues that they can support. They may even have limits on supported credit window combinations. For example, per destination queues may not be supported at all. When modem-provided credit window information exceeds the capabilities of a router, the router SHOULD use a subset of the provided credit windows. Alternatively, a router MAY reset the session and indicate that the extension is not supported. In either case, the mismatch of capabilities SHOULD be reported to the user via normal network management mechanisms, such as the user interface or error logging.

In all cases, if credit windows are in use, traffic for which credits are not available MUST NOT be sent to the modem by the router.

3. Compatibility

The messages and Data Items defined in this document will only be used when extensions require their use.

The DLEP specification [RFC8175] defines handling of unexpected appearances of any Data Items, including those defined in this document.

4. Security Considerations

This document introduces credit window control and flow mechanisms to DLEP. These mechanisms expose vulnerabilities similar to existing DLEP messages. An example of a threat to which flow control might be susceptible is a malicious actor masquerading as a DLEP peer could inject a Credit Window Initialization Data Item, which resizes a credit window to a value that results in a denial of service. Other possible threats are given in the Security Considerations of [RFC8175] and are also applicable to, but not specific to, flow control. The transport layer security mechanisms documented in [RFC8175], with some updated references to external documents listed below, can be applied to this document. Implementations following the "networked deployment" model described in the "Implementation Scenarios" of [RFC8175] SHOULD refer to [BCP195] for additional details. The Layer 2 security mechanisms documented in [RFC8175] can also, with some updates, be applied to the mechanism defined in this document. Examples of technologies that can be deployed to secure the Layer 2 link include [IEEE-802.1AE] and [IEEE-8802-1X].

5. IANA Considerations

This document requests the assignment of several values by IANA. All assignments are to registries defined by [RFC8175].

5.1. Message Type Values

This document requests 2 new assignments to the DLEP Message Registry named "Message Values" in the range with the "Specification Required" policy. The requested values are as follows:

Type Code	Description
TBA2	Credit Control
TBA3	Credit Control Response

Table 1: Requested Message Type Values

5.2. Data Item Values

This document requests the following new assignments to the DLEP Data Item Registry named "Data Item Type Values" in the range with the "Specification Required" policy. The requested values are as follows:

Type Code	Description
TBA4	Credit Window Initialization
TBA5	Credit Window Association
TBA6	Credit Window Grant
TBA7	Credit Window Status
TBA8	Credit Window Request

Table 2: Requested Data Item Values

6. References

6.1. Normative References

- [I-D.ietf-manet-dlep-traffic-classification]
 Cheng, B., Wiggins, D., Berger, L., and D. Fedyk, "Dynamic Link Exchange Protocol (DLEP) Traffic Classification Data Item", Work in Progress, Internet-Draft, draft-ietf-manet-dlep-traffic-classification, 19 November 2024, <<https://datatracker.ietf.org/doc/draft-ietf-manet-dlep-traffic-classification>>.

- [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

- [BCP195] Best Current Practice 195, <<https://www.rfc-editor.org/info/bcp195>>. At the time of writing, this BCP comprises the following:
- Sheffer, Y., Saint-Andre, P., and T. Fossati, "Recommendations for Secure Use of Transport Layer Security (TLS) and Datagram Transport Layer Security (DTLS)", BCP 195, RFC 9325, DOI 10.17487/RFC9325, November 2022, <<https://www.rfc-editor.org/info/rfc9325>>.
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Appendix A. Acknowledgments

We mourn the loss of Stan Ratliff who passed away on October 22, 2019. His guidance, leadership and personal contributions were critical in the development of this work and DLEP as a whole. His leadership and friendship shall be missed.

We had the honor of working too briefly with David Wiggins on this and related DLEP work. His contribution to the IETF and publication of the first and definitive open source DLEP implementation have been critical to the acceptance of DLEP. We mourn his passing on November 23, 2023. We wish to recognize his guidance, leadership and professional excellence. We were fortunate to benefit from his leadership and friendship. He shall be missed.

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Appendix B. Example DLEP Credit Flow Control and Traffic Classification Data Item Exchange

Below Figure 2 illustrates a credit flow control and traffic classification exchange between a Router and a Modem. The Modem will initialize a number of queues with Credit Window Initialization Data Items, Window Association Data Item(s) and Traffic Classification Item(s) included in DLEP messages as outlined in this document. If the Data Items are successfully validated, traffic is mapped to the corresponding credit window on the router and forwarded when there are sufficient credits. Routers can periodically report the status of the credit window. Modems will send periodic updates with more credits as packets are transmitted. Routers may request more credits for a particular window if the router requires more credits. This document defines window credit flow information for flow Identifiers (FIDs) that map to the queues. [I-D.ietf-manet-dlep-traffic-classification] defines the traffic classification data sub items such as DiffServ code points that map to the FIDs.

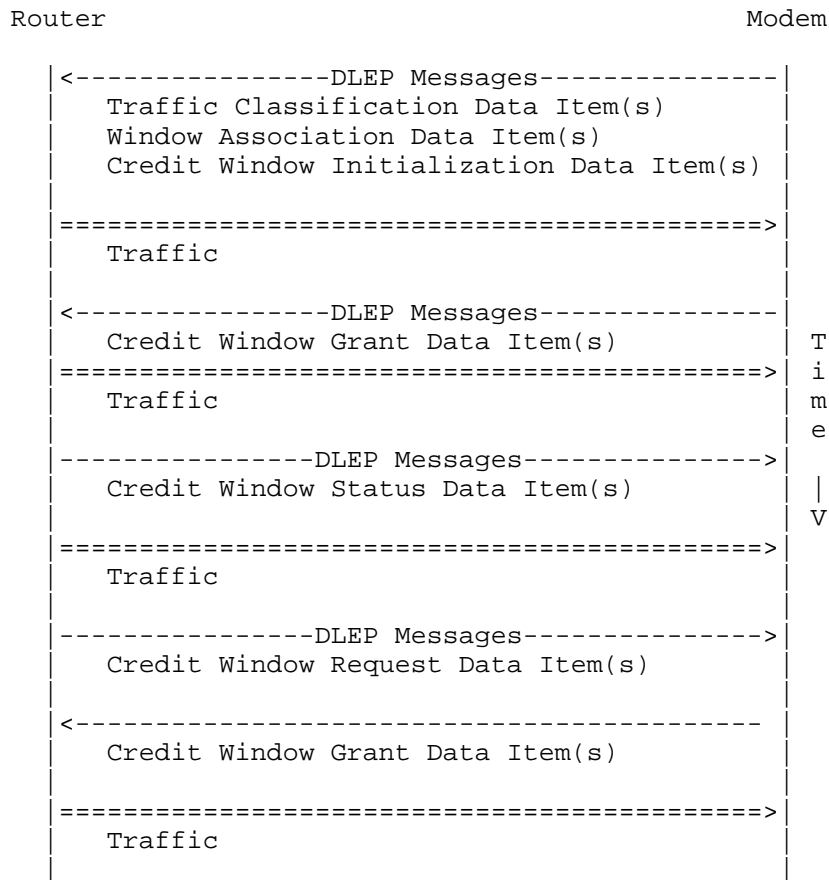


Figure 2: Example DLEP Traffic Classification/Credit Flow Exchange

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