Network Working Group
Internet Draft
Updates: 3477, 4206
Proposed Category: Proposed Standard

Expires: September 2006

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March 6, 2006

Advertisement of hierarchical and stitchable Label Switched Paths as Traffic Engineering Links
draft-shiomoto-ccamp-lsp-hierarchy-bis-01.txt

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Abstract

This document addresses topics related to hierarchical and stitched Generalized Multiprotocol Label Switching (GMPLS) Label Switched Paths (LSPs). It describes extensions to allow an egress to identify that a bi-directional LSP will be used as a dynamically signaled Forwarding Adjacency LSP (FA-LSP) or Routing Adjacency (RA). In addition, the document also addresses the issue of how to indicate that an LSP should be advertised as a traffic engineering (TE) link into a different instance of the IGP and how to identify the instance that should be used.

Conventions used in this document

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 [RFC2119].

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1. Introduction and Problem Statement

1.1. LSP Hierarchy

LSP hierarchy has been developed to improve the scalability of Generalized Multi-Protocol Label Switching (GMPLS) by allowing Label Switched Paths (LSPs) to be aggregated into a hierarchy of such LSPs [RFC4206]. An LSP may be advertised as a traffic engineering (TE) link for use within the same instance of the control plane as was used to set up the LSP. This TE link is called a Forwarding Adjacency (FA), and the LSP is known as an FA-LSP.

[RFC4206] defines the operation as follows for a numbered FA:

1. The ingress signals the LSP using a /31 sender address that it allocates as the source address in the signaling message (tunnel sender address in the Sender Template object of the Path message), and targeting the TE router ID of the egress (destination address in the Sender object of the Path message).

2. The egress sets up the LSP using normal procedures and allocating the partner address of the assigned /31 address in the local interface address.

3. The ingress then forms a Forwarding Adjacency (FA) out of that LSP by advertising it as a Traffic Engineering (TE) link using the routing protocol (OSPF/ISIS) and using the /31 address to identify the local end of the TE link.

4. When the egress receives the TE link advertisement, it checks the Link-ID address of the TE advertisement against its own TE Router ID. If it matches its own TE Router ID, the egress checks the advertising router ID of the TE advertisement against the ingress addresses of all LSPs for which it is the egress and finds the address match with the advertising router ID of the TE advertisement.

5. The egress then advertises the FA LSP as a TE link setting the advertising TE Router ID in the Link-ID and the partner address of the assigned /31 address in the local interface address.

Nesting of LSPs originated by other LSRs into that LSP can be achieved by using the label stack construct.

1.2. LSP advertisement and Usage

There are three different ways in which traffic can be forwarded to an LSP. Similarly, the LSP can be advertised into the IP topology, the MPLS TE topology or both, depending on the intended usage.

As GMPLS LSPs can be bidirectional, full routing adjacencies can be established over a bidirectional GMPLS LSP. When an LSP is used as an RA, it is advertised into IP network and can optionally be advertised into the MPLS topology. The notion of RA is only applicable to bidirectional LSPs.

As mentioned above, there is no IGP adjacency over the LSP, when it is to be used as an FA. FA-LSPs can be advertised into the IP and/ or MPLS topologies. Notion of FA is equally applicable to the unidirectional as well as bidirectional LSPs.

There are also scenarios where intent of establishing an LSP is to use it for traffic local to the Ingress/ Egress LSRs. In this case, the LSP is neither advertised into the IP nor in MPLS topologies. In this document, such LSPs are referred as local virtual links. Forwarding treatment for a local virtual link is based on a local decision.

1.3. Problem Statement

The extensions described in this document are intended for dynamically signaled bi-directional Forwarding Adjacency LSPs (FA-LSPs). In particular this document addresses the following points:

(1) How to let the egress node know that this bi-directional LSP needs to be advertised as an FA, or as routing adjacency (RA), or its only to be used at the Ingress and Egress nodes.

(2) How to identify the routing instance in which such an advertisement should happen.

We should note that these aspects are equally applicable to both numbered and unnumbered TE links.

In order for the egress of an LSP to be able to advertise the LSP as a TE link it needs to know that such an advertisement is desirable, and it also needs to know the TE Router ID of the ingress LSR. (Please recall that the Router ID of the other end of the link is set

in the Link-ID sub-TLV of the Link TLV of the TE Opaque-LSA [RFC3630].)

The mechanism set out in section 1.1 is used for numbered FAs because there is no way to carry the TE Router ID of the ingress LSR in the RSVP signaling message (Path message) and there is no way to indicate that the new LSP is to be used as an FA LSP. Therefore the egress LSR has to wait to receive the ingress' advertisement of the TE link to learn that the LSP is to form a TE link and to learn the TE Router ID of the ingress node before it can advertise the FA as described in Section 1.2. Note further, that in this approach, the egress LSR must search potentially many LSPs every time it receives an advertisement for a new TE link.

[RFC3477] defines a different method for the exchange of information in the signaling protocol during the establishment of LSPs that will be advertised as unnumbered TE links. If the LSP_TUNNEL_INTERFACE_ID object is present, it indicates that the LSP is to be advertised as a TE link, and it contains the TE Router ID of the ingress LSR. However, the LSP_TUNNEL_INTERFACE_ID object cannot be used for numbered FAs as currently defined.

Related to the above problem, a few key observations are worth noting:

1. The term FA is applicable only when an LSP is created and used as a TE link in the same instance of the IGP. [RFC4206] did not consider scenarios where an LSP is created (and maintained) by one instance of the IGP, and is used as a (TE) link by another instance of IGP. This leaves open the question of advertising a TE link into a different instance of the IGP as is needed in multi-region/multi-layer networks [MLN], and how to identify which instance of the IGP should be used. In addition, the TE link advertised into the different IGP instance may be associated with an IGP neighbor adjacency. We call it a routing adjacency (RA). The decision as to whether the link should be advertised to MPLS TE topology or IP topology or both depends on operator policy. Therefore, a mechanism to indicate the choice to the Egress node is needed.

2. [RFC4206] provides a way to exchange numbered identifiers for the TE link, but this does not clearly state that the Ingress node can use presence of the LSP_TUNNEL_INTERFACE_ID object as a trigger for TE link advertisement at the egress node.

3. It is important to note that an LSP that is set up in a server GMPLS transport network and advertised as a TE link in a client MPLS data network is NOT an FA-LSP according to the definitions explained in point 1, above. This is the case regardless of whether the GMPLS network is packet- or non-packet-capable.

4. When an egress checks the address of the advertised TE link to find the LSP sender (Recall step (4) as described in section 1.1), it must check the Link-ID address of all received TE advertisements against its own TE Router ID. If it matches its own TE Router ID, the egress checks the advertising router ID of the TE advertisement against the ingress addresses of all LSPs for which it is the egress. It is an assertion of the authors that this method is not scalable due to the amount of processing needed for all the TE Link State Advertisements (LSAs).

1.4. Current Approaches and Shortcomings

[RFC3477] provides a mechanism to exchange unnumbered identifiers for the TE link during FA-LSP establishment, and this can be used as a notification to the egress that the LSP will be used as a TE link. So, for unnumbered TE links, there is a well-defined indication available, and this could be documented and used as a trigger for TE link advertisement by the egress.

The use of unnumbered TE links may be arguably more sensible than assigning numbers to FAs, especially in the case of large networks. Some operators though prefer to consistently use numbered TE links for both static and dynamic (that is, FA) TE links in their networks. In the case of numbered TE links, however, there is no available indication to allow the egress to know that an LSP should be advertised as a TE link.

In addition, using unnumbered TE links does not address the issue of advertising TE links into a different instance of the IGP. There is no defined mechanism to identify whether it should be advertised as an FA, a full Routing Adjacency (RA), or a static link.

The Link Management Protocol (LMP) [RFC4204] could possibly be run on remote adjacencies between the endpoints of an LSP. But LMP peer discovery would be required for dynamic LMP peering and is not currently specified. In addition, the concept of a remote LMP adjacency remains unproven. Lastly, there would be a requirement that all layers/regions in a MLN network run LMP. This may not be the case in existing networks and would put undue burden on the network operator to deploy another protocol.

1.5. Contents of This Document

This document provides a consolidated way of exchanging TE link identifiers when an LSP is established through signaling. It also provides a mechanism to allow the ingress to control whether, and into which IGP instances, an LSP is advertised as an FA and/ or RA by the egress. The proposed mechanism applies equally to Hierarchical LSPs (H-LSPs) and Stitchable LSPs (S-LSPs).

The method described below extends the method described in [RFC3477], which is applied for an FA-LSP represented as an unnumbered TE link.

2. Proposed Solution

The following method allows the ingress and egress LSRs to exchange the link addresses or link identifiers (including the node ID) of the ends of a numbered or unnumbered TE link to be formed from an LSP. It is an extension of the procedures defined in [RFC3477] for unnumbered TE links.

If an Ingress LSR, that originates an LSP, intends to advertise this LSP as a TE link in IS-IS or OSPF [RFC4206], the Ingress LSR MUST allocate an address or identifier to the TE link (just like for any other TE link), and it MUST do this before the LSP setup request is signaled. Moreover, the Path message used for establishing the LSP that will be used to form the TE link MUST contain the LSP_TUNNEL_INTERFACE_ID object (as extended and described below), with the interface address or identifier allocated by the Ingress LSR.

If the Path message for the H-LSP/S-LSP contains the LSP_TUNNEL_INTERFACE_ID object, then the Egress LSR (assuming it accepts the LSP request) MUST allocate an address or identifier to the TE link that will be formed (just like for any other numbered or unnumbered TE link). Furthermore, the Resv message for the LSP MUST contain an LSP_TUNNEL_INTERFACE_ID object, with the interface address or identifier allocated by the Egress LSR.

In all cases where an LSP is to be advertised as a TE link, the Tunnel Sender Address in the Sender Template Object of the Path message MUST be set to the TE Router ID of the Ingress LSR. We should note that this is a change from the method described in [RFC4206].

Once the Egress LSR has successfully sent a Resv message as described above it SHOULD advertise the LSP as a TE link using the addresses/identifiers exchanged. Once the Resv has been processed by the Ingress LSR and the LSP has been successfully established, the

Ingress LSR SHOULD advertise the LSP as a TE link using the addresses/identifiers exchanged.

Once the TE link advertisement has been flooded it is available for use in path computation and LSP signaling just like any other TE link.

2.1. IGP Instance Identification

The mechanism described so far allows an Ingress LSR to indicate that an LSP is to be used as a TE link and allows the Ingress and Egress LSRs to exchange addresses or identifiers for that TE link, during LSP setup.

However, it is also necessary to indicate into which instance of the IGP the advertisement should be made. This is only necessary if the LSP is to be advertised as a TE link into a different instance of the IGP, and the default behavior may safely be left with the LSP advertised into the same instance of the IGP (that is, FA behavior).

Indication of the IGP in which the advertisement is to be made first requires that a 32-bit identifier be assigned to each of the IGP instances within a network, and that Ingress and Egress LSRs have the same understanding of these numbers. This is a management configuration exercise outside the scope of this document.

Once these numbers have been assigned, they MAY be signaled as additional information in the LSP_TUNNEL_INTERFACE_ID object to indicate to which instance of the IGP the object applies.

The IGP instance identifier value of 0xffffffff is reserved to indicate that the TE link SHOULD be advertised into the same instance of the IGP as was used to establish the LSP. Similarly, absence of the IGP instance identifier means that an FA is to be established (in the same IGP instance).

2.2. LSP advertisement and Usage Identification

As mentioned earlier, the Egress node also needs to know if it needs to create a full routing adjacency or forwarding adjacency or just need to treat the LSP as a local virtual link. The extensions defined in the following also specify the LSP advertisement and usage treatment.

2.3. LSP_TUNNEL_INTERFACE_ID Object

The LSP_TUNNEL_INTERFACE_ID object defined in [RFC3477] has a class number of 193, which designates that a node that does not understand the object SHOULD ignore the object but forward it, unexamined and unmodified, in all messages resulting from this message.

[RFC3477] defines one class type to indicate an unnumbered interface identifier. This document defines three new class types as follows.

C-Type	Meaning	Reference
1	Unnumbered interface identifier	[RFC3477]
2 (TBD by IANA)	IPv4 interface identifier with target	2.2.2
3 (TBD by IANA)	IPv6 interface identifier with target	2.2.3
4 (TBD by IANA)	Unnumbered interface with target	2.2.4

Multiple instances of the LSP_TUNNEL_INTERFACE_ID object with C-Type values 2, 3 or 4 MAY appear in any one Path or Resv message, in which case, each MUST have a different value for the Target IGP Instance field. A Path or Resv message MUST NOT contain more than one instance of the LSP_TUNNEL_INTERFACE_ID object with C-Type 1, and if such an object is present, other instances of the object with any other C-Type value MUST NOT have Target IGP Instance set to 0xffffffff.

2.3.1. Unnumbered link

The unnumbered link identifier defined by [RFC3477] is not changed by this document. Its usage also remains the same. That is, when present in a Path message it indicates that the LSP being established SHOULD be advertised by the egress LSR as a TE link, and that unnumbered link identifier is the ingress' identifier for the TE link.

Note that since this form of the object does not contain a target IGP instance identifier it cannot identify a specific instance of the IGP into which this TE link should be advertised. Similarly, LSP advertisement and usage treatment also needs to be specified. Thus, when C-Type 1 is used, the TE link SHOULD be advertised only into the same instance of the IGP as was used to create the LSP. That is, the use of C-Type 1 is unchanged from [RFC3477] and is used to create an unnumbered Forwarding Adjacency.

This object can appear in either a Path message or a Resv message. In the former case, we call it the "Forward Interface ID" for that

LSP; in the latter case, we call it the "Reverse Interface ID" for the LSP.

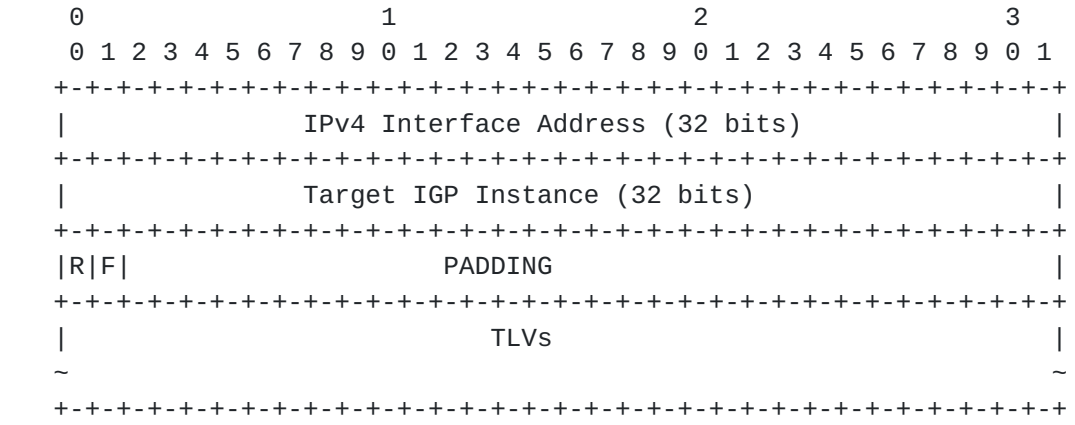
Only one instance of this object with C-Type 1 may be present on a Path or Resv message.

2.3.2. IPv4 numbered link

A new C-Type variant of the LSP_TUNNEL_INTERFACE_ID Object is defined to carry an IPv4 numbered interface address and to indicate into which instance of the IGP the consequent TE link should be advertised.

The format of the object is as shown below.

C-NUM = 193, C-Type = 2(TBD by IANA)



R: The R bit is set to indicate the Egress LSR to establish a full routing adjacency over this bidirectional LSP. When R bit is set, the bidirectional LSP is advertised into the IP topology.

F: The F bit is set to indicate the Egress LSR to advertise this LSP into MPLS TE topology.

It is important to note that R and F bits can be set independent of each other. That is,

R = 1, F = 0: LSP is an RA and is only advertised into the IP network.

R = 1, F = 1: LSP is an RA and is advertised in both IP and MPLS-TE topologies.

R = 0, F = 1: LSP is an FA and is only advertised into the MPLS-TE topology.

R = 0, F = 0: LSP is neither the FA nor RA and is to be used as a local virtual link. In this case the LSP is advertised neither in IP nor MPLS topology.

The Padding MUST be set to zero on transmission, SHOULD be ignored and forwarded unchanged, and SHOULD be ignored on receipt.

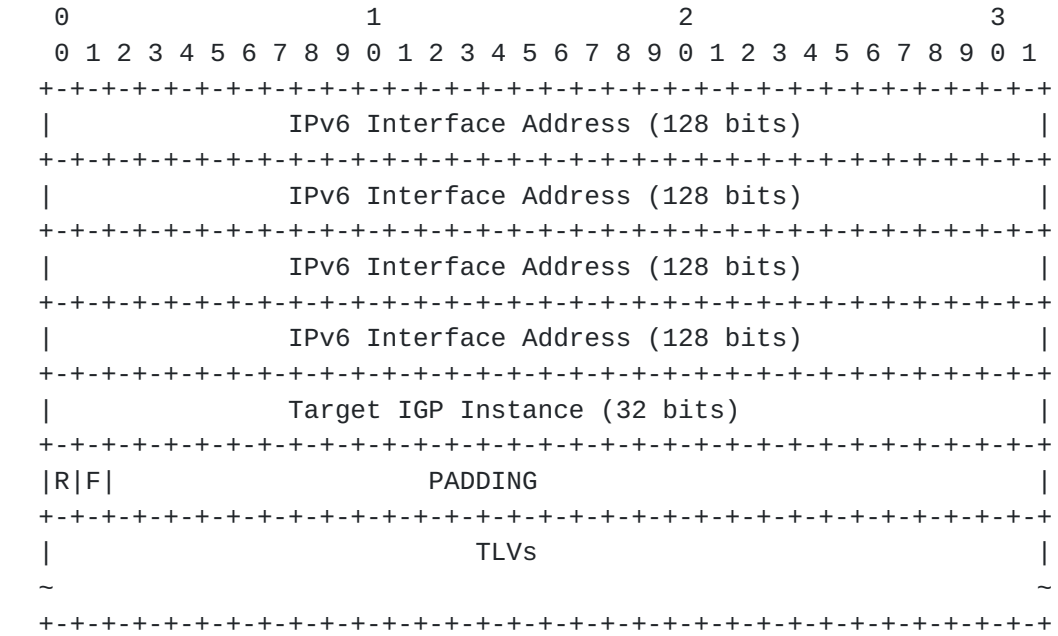
This object can appear in either a Path message or a Resv message. In the former case, we call it the "Forward Interface Address" for that LSP; in the latter case, we call it the "Reverse Interface Address" for the LSP.

2.3.3. IPv6 numbered link

A new C-Type variant of the LSP_TUNNEL_INTERFACE_ID Object is defined to carry an IPv6 numbered interface address and to indicate into which instance of the IGP the consequent TE link should be advertised.

The format of the object is as shown below.

C-NUM = 193, C-Type = 3(TBD by IANA)



This object can optionally appear in either a Path message or a Resv message. In the former case, we call it the "Forward Interface

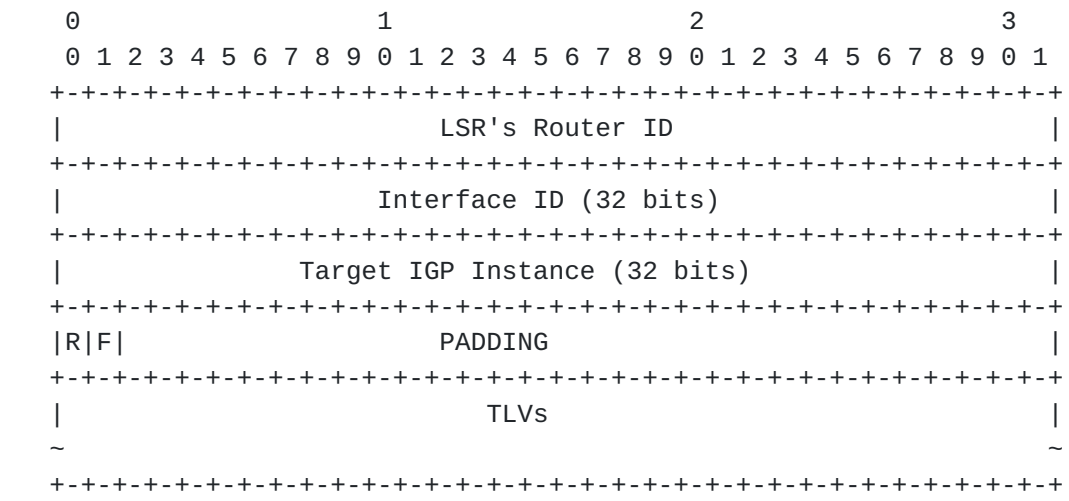
Address" for that LSP; in the latter case, we call it the "Reverse Interface Address" for the LSP.

2.3.4. Unnumbered link with target IGP instance identifier

A new C-Type variant of the LSP_TUNNEL_INTERFACE_ID Object is defined to carry an unnumbered interface identifier and to indicate into which instance of the IGP the consequent TE link should be advertised. This does not deprecate the use of C-Type 1, but extends its utility.

The format of the object is as shown below.

C-NUM = 193, C-Type = 4(TBD by IANA)



This object can optionally appear in either a Path message or a Resv message. In the former case, we call it the "Forward Interface ID" for that LSP; in the latter case, we call it the "Reverse Interface ID" for the LSP.

2.3.5. Message Formats

[RFC3477] does not state where in the Path message or Resv message the LSP_TUNNEL_INTERFACE_ID object should be placed. Since [RFC3209] states that all implementations are to handle all objects received in any order, this is not a problem. However, it is RECOMMENDED that the LSP_TUNNEL_INTERFACE_ID object(s) be placed in the Path message immediately after the SENDER_TSPEC object, and in the Resv message immediately after the FILTER_SPEC object.

2.4. LSA advertisement

The ingress and egress LSRs MAY advertise link state associated with TE links created as described above. The link state may be advertised in either the same IGP instance as used to compute and signal the path for the LSPs that support the TE links, or another IGP instance. In the former case, the address space for the link state MUST be the same as that used to establish the LSPs. In the latter case, the address space for the link state MAY be different, which means that addresses already allocated in the IGP instance used to establish the LSPs MAY be used by the advertised TE link without any ambiguity.

In the IGP the TE Router ID of the ingress LSR is taken from the Tunnel Sender Address in the Sender Template object. It is assumed that the ingress LSR knows the TE Router ID of the egress LSR since it has chosen to establish an LSP to that LSR and plans to use the LSP as a TE link.

The link interface addresses or link interface identifiers for the forward and reverse direction links are taken from the LSP_TUNNEL_INTREFACE_ID object on the Path and Resv messages respectively.

Address overlap checking for these objects MUST be turned off when the LSA is advertised into a IGP instance different from the one used to establish the LSP because the addresses MAY be allocated in both domains.

3. Applicability Statement

The method is applicable for both hierarchical LSPs [RFC4206] and LSP stitching [STITCH].

4. Backward Compatibility Considerations

The method does not impact the method to exchange unnumbered FA information described in [RFC3477]. That mechanism can be safely used in combination with the new mechanisms described here and is functionally equivalent to using the new C-Type indicating an unnumbered link with target IGP instance identifier with the Target IGP Instance value set to 0xffffffff.

This method obsoletes the method to exchange the numbered FA information described in [RFC4206]. This is not believed to be an issue as an informal survey indicated that dynamically signaled

numbered FAs had not been deployed. Indeed it was the attempt to implement numbered FAs that gave rise to the work on this document.

5. Security Considerations

[RFC3477] points out that one can argue that the use of the extra interface identifier that it provides could make an RSVP message harder to spoof. In that respect, the minor extensions to the protocol made in this document do not constitute an additional security risk, but could also be said to improve security.

It should be noted that the ability of an ingress LSR to request that an egress LSR advertise an LSP as a TE link MUST be subject to appropriate policy checks at the egress LSR. That is, the egress LSR MUST NOT automatically accept the word of the ingress unless it is configured with such a policy.

6. IANA Considerations

This document defines three new C-Types for the LSP_TUNNEL_INTERFACE_ID object. The C-Types for this object are managed by IANA, and IANA is requested to assign values to the new C-Types as tabulated in section 2.2 and described in sections 2.2.2, 2.2.3 and 2.2.4.

7. Acknowledgement

The authors would like to thank John Drake for valuable discussions and comments.

Funding for the RFC Editor function is currently provided by the Internet Society.

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