

Network Working Group  
Request for Comments: 3528  
Category: Experimental

W. Zhao  
H. Schulzrinne  
Columbia University  
E. Guttman  
Sun Microsystems  
April 2003

## Mesh-enhanced Service Location Protocol (mSLP)

### Status of this Memo

This memo defines an Experimental Protocol for the Internet community. It does not specify an Internet standard of any kind. Discussion and suggestions for improvement are requested. Distribution of this memo is unlimited.

### Copyright Notice

Copyright (C) The Internet Society (2003). All Rights Reserved.

### Abstract

This document describes the Mesh-enhanced Service Location Protocol (mSLP). mSLP enhances the Service Location Protocol (SLP) with a scope-based fully-meshed peering Directory Agent (DA) architecture. Peer DAs exchange new service registrations in shared scopes via anti-entropy and direct forwarding. mSLP improves the reliability and consistency of SLP DA services, and simplifies Service Agent (SA) registrations in systems with multiple DAs. mSLP is backward compatible with SLPv2 and can be deployed incrementally.

### Table of Contents

1.	Introduction . . . . .	2
1.1.	Notation Conventions . . . . .	2
1.2.	Terminology . . . . .	3
1.3.	Compatibility . . . . .	3
2.	Scope-based Fully-meshed Peering DA Architecture . . . . .	4
3.	Peer Relationship Management . . . . .	6
3.1.	Learning about New Peers . . . . .	6
3.2.	Establishing a Peering Connection . . . . .	6
3.3.	Exchanging Information about Existing Peers . . . . .	6
3.4.	Maintaining a Peer Relationship . . . . .	7
3.5.	Tearing Down a Peer Relationship . . . . .	7
4.	Registration Propagation Control . . . . .	7
4.1.	Accept ID and Propagation Order . . . . .	7
4.2.	Version Timestamp and Registration Version Resolution . . . . .	8

4.3.	Mesh Forwarding Extension . . . . .	8
4.4.	Summary Vector . . . . .	9
4.5.	Service Deregistration . . . . .	10
4.6.	Anti-entropy Request Message . . . . .	10
4.7.	Anti-entropy . . . . .	11
4.8.	Direct Forwarding . . . . .	11
4.9.	SrvAck Message . . . . .	12
4.10.	Control Information . . . . .	12
5.	Summary . . . . .	12
6.	Protocol Timing Defaults . . . . .	13
7.	IANA Considerations . . . . .	13
8.	Security Considerations . . . . .	13
9.	Acknowledgments . . . . .	13
10.	References . . . . .	13
10.1.	Normative References . . . . .	13
10.2.	Informative References . . . . .	14
11.	Authors' Addresses . . . . .	14
12.	Full Copyright Statement . . . . .	15

## 1. Introduction

In the Service Location Protocol (SLPv2 [RFC2608]), Directory Agents (DAs) accept service registrations from Service Agents (SAs) and answer queries from User Agents (UAs); they enhance the performance and scalability of SLPv2. The use of scopes in SLPv2 further improves its scalability. In general, a DA can serve multiple scopes, and a scope can be served by multiple DAs. When multiple DAs are present for a scope, how should they interact with each other? This document describes the Mesh-enhanced Service Location Protocol (mSLP), addressing this open issue in SLPv2.

mSLP defines a scope-based fully-meshed peering DA architecture: for each scope, all DAs serving the scope form a fully-meshed peer relationship (similar to IBGP [RFC1771]). Peer DAs exchange new service registrations in shared scopes via anti-entropy [EPID-ALGO,UPDA-PROP] and direct forwarding. mSLP improves the reliability and consistency of SLP DA services, and simplifies SA registrations in systems with multiple DAs.

### 1.1. Notation Conventions

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].

## 1.2. Terminology

### Peer DAs (or Peers)

DAs that share one or multiple scopes are peers.

### Peering Connection

A persistent connection (e.g., TCP) that provides reliable and ordered transfers between two peers. The closing of a peering connection terminates the peer relationship.

### Mesh-enhanced DA (MDA)

An MDA carries the "mesh-enhanced" attribute keyword in its DA Advertisement (DAAdvert) message, maintains peering connections to all peers, and properly interacts with peers.

### Mesh-enhanced SA (MSA)

An MSA uses the Mesh Forwarding extension (Section 4.3) when it registers with MDAs.

### Registration Update

A registration update refers to a Service Registration (SrvReg) or Service Deregistration (SrvDeReg) message.

### Registration State

A registration state refers to an entry in the registration database.

### Accept DA

When a DA accepts a registration update from an SA, the DA is the accept DA for the update.

### Accept Timestamp

The arrival timestamp of a registration update at its accept DA is the accept timestamp of the update. All accept timestamps assigned by the same DA MUST be monotonically increasing.

### Version Timestamp

When an MSA sends a registration update to an MDA, the MSA assigns a version timestamp to the update. All version timestamps assigned by the same MSA MUST be monotonically increasing.

## 1.3. Compatibility

mSLP is designed as a lightweight enhancement to SLPv2. It is backward compatible with SLPv2. mSLP defines two enhanced entities: MDAs and MSAs. They can be deployed incrementally. An enhanced entity supports extended operations without affecting its original functionality as defined in RFC 2608 [RFC2608]. For simplicity and





### 3. Peer Relationship Management

#### 3.1. Learning about New Peers

An MDA can learn about new peers via static configuration, DHCP [RFC2610], and DAAdvert multicast and unicast. In any case, an MDA **MUST** get a peer's DAAdvert before establishing a peer relationship to the peer.

#### 3.2. Establishing a Peering Connection

After getting a new peer's DAAdvert, an MDA establishes a peering connection (if such a connection does not exist yet) to the peer, and sends its DAAdvert via the connection (Figure 3). An MDA can identify a peering connection initiated by a peer by receiving the peer's DAAdvert from the connection. Normally, a single peering connection is set up between two peers, but there is a small possibility that a pair of peering connections might be created between two peers if they try to initiate a connection to each other at almost the same time. Thus, when an MDA identifies a new peering connection initiated by a peer, it **SHOULD** check whether it has initiated another peering connection to the peer. If this is the case, and it has a lower-numbered IP address than the peer, then the MDA **SHOULD** terminate the connection it has initiated.

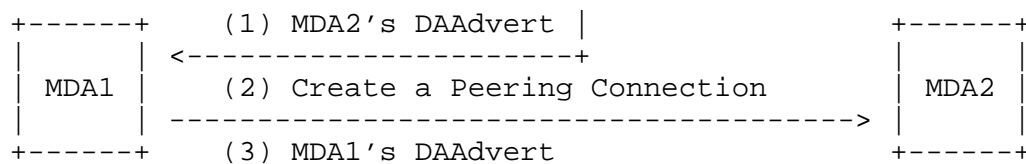


Figure 3. Establishing a peering connection

#### 3.3. Exchanging Information about Existing Peers

After establishing a peering connection, two peers (say, MDA1 and MDA2) exchange information about their existing peers by forwarding peers' DAAdverts via the peering connection (Figure 4). MDA1 will forward the DAAdvert of a peer (say, MDA3) to MDA2 if:

- (1) MDA3 shares scopes with MDA2, and
- (2) MDA3 is an active peer of MDA1 (i.e., there is a peering connection between MDA3 and MDA1) or an accept DA for registrations currently maintained by MDA1 (i.e., MDA1 has registrations originally accepted by MDA3).

MDA2 operates similarly. Note that all DAAdverts can be sent as one TCP stream for efficiency. Exchanging information about existing peers enables an MDA to learn about new peers incrementally.

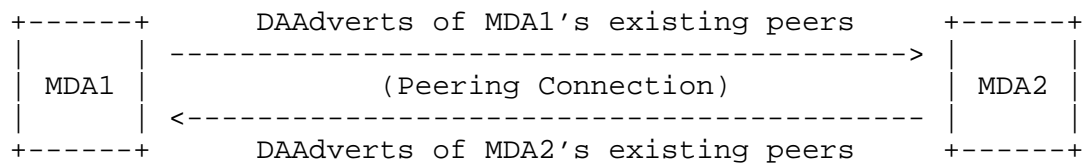


Figure 4. Exchanging information about existing peers

### 3.4. Maintaining a Peer Relationship

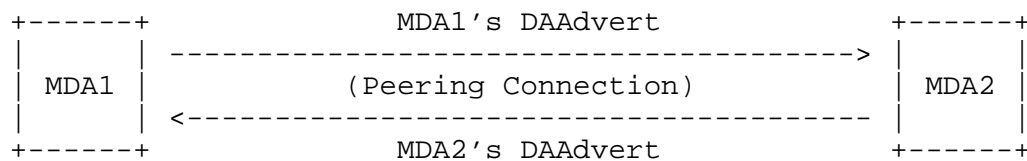


Figure 5. Maintaining a peer relationship

To detect failures (network partitions and peer crashes), mSLP uses a heart-beat mechanism. An MDA sends its DAAdvert to peers (Figure 5) every CONFIG\_DA\_KEEPLIVE seconds. The timeout value for this message is CONFIG\_DA\_TIMEOUT seconds (Section 6).

### 3.5. Tearing Down a Peer Relationship

An MDA SHOULD tear down a peer relationship when it finds that the peer has closed the peering connection, when it receives a DAAdvert multicast from the peer with a DA stateless boot timestamp set to 0 (meaning that the peer is going to shutdown), or when it has not received the peer's DAAdvert for more than CONFIG\_DA\_TIMEOUT seconds.

## 4. Registration Propagation Control

### 4.1. Accept ID and Propagation Order

When an MDA accepts a registration update from an MSA, the MDA assigns a unique accept ID to the update. An accept ID has two components: an accept DA URL and an accept timestamp. The accept timestamp is a 64-bit integer representing elapsed microseconds since 00:00 Coordinated Universal Time (UTC), January 1, 1900. Figure 6 shows the format for an accept ID entry. A registration state has the same accept ID as that of the latest update applied to it.

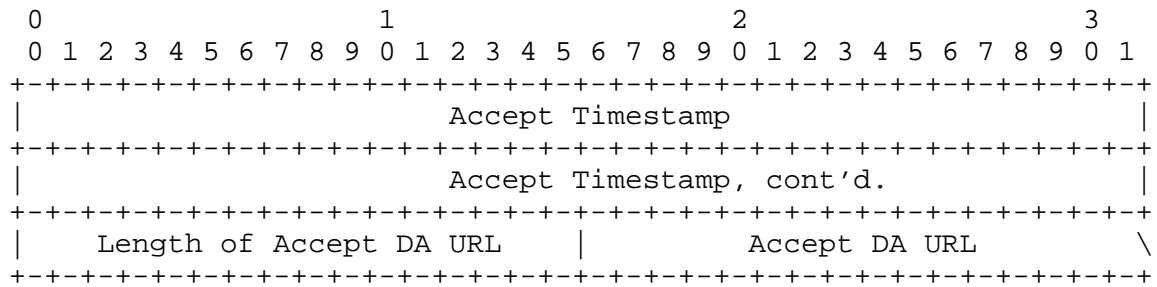


Figure 6. Accept ID entry

An MDA MUST propagate registrations in the increasing order of their accept IDs, i.e., registrations having the same accept DA MUST be propagated in the increasing order of their accept timestamps. Note that registrations having different accept DAs MAY be propagated in any order.

#### 4.2. Version Timestamp and Registration Version Resolution

When registrations are propagated among MDAs, their arrival timestamps at MDAs cannot be used for version resolution. For example, assume that MSA1 sends a registration (R1) to MDA1 first, and a new version of the same registration (R2) to MDA2 later. When R1 and R2 are propagated, the arrival timestamp of R1 at MDA2 is later than that of R2, but R1 SHOULD NOT overwrite R2 at MDA2 as R2 is a newer version.

mSLP resolves registration versions using version timestamps. When an MSA sends a registration update to an MDA, the MSA assigns a version timestamp to the update. The version timestamp is a 64-bit integer representing elapsed microseconds since 00:00 UTC, January 1, 1900. mSLP assumes that each registration is updated only by one SA, thus an MDA does not need to compare version timestamps from different MSAs. An MDA installs a registration update if the update has a newer version timestamp (from an MSA), or the update does not have the Mesh Forwarding extension (from a non-MSA).

#### 4.3. Mesh Forwarding Extension

The Mesh Forwarding (MeshFwd) extension carries a version timestamp and an accept ID entry. Figure 7 shows its format and two defined Forwarding IDs (Fwd-IDs).

The MeshFwd extension is used with a Srv(De)Reg message, but it can only be used with a fresh SrvReg, or a complete SrvDeReg.



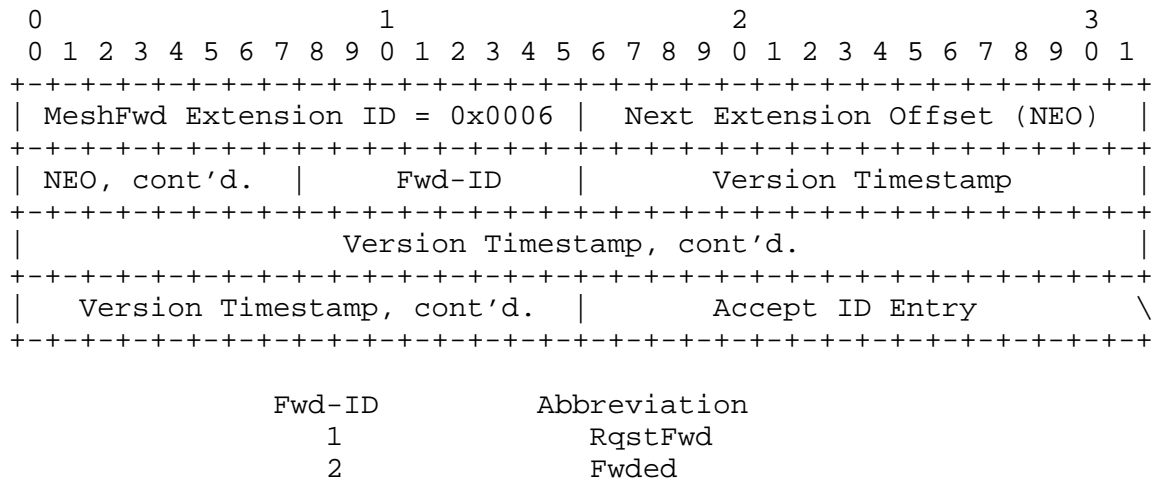


Figure 7. MeshFwd extension and its Fwd-IDs

An MSA uses the RqstFwd MeshFwd extension (Fwd-ID = RqstFwd, accept timestamp = 0) in a Srv(De)Reg to explicitly request an MDA (the accept DA) to forward the message.

An MDA uses the Fwded MeshFwd extension (Fwd-ID = Fwded, accept timestamp != 0) in each Srv(De)Reg sent from it to another MDA, either forwarding a Srv(De)Reg received from an MSA (if the message has the RqstFwd MeshFwd extension), or propagating a registration state in its database.

#### 4.4. Summary Vector

An MDA uses a summary vector to represent its received Srv(De)Reg(s) that have a MeshFwd extension. This summary vector records the latest accept timestamp for each accept DA that appears in the MeshFwd extension. For example, consider n MDAs for a scope, if MD*A*<sub>*i*</sub> has a summary vector as ((MDA<sub>1</sub>, T<sub>1</sub>), (MDA<sub>2</sub>, T<sub>2</sub>), ..., (MDA<sub>*n*</sub>, T<sub>*n*</sub>)), then MD*A*<sub>*i*</sub> has received all registrations originally accepted by MD*A*<sub>*j*</sub> up to timestamp T<sub>*j*</sub>, where 1 ≤ *i*, *j* ≤ *n*.

An MDA updates its summary vector when it receives a Srv(De)Reg that has a MeshFwd extension. The MDA adds a new accept ID to its summary vector if the Srv(De)Reg has a new accept DA; the MDA updates the accept timestamp of an existing accept ID in its summary vector if the Srv(De)Reg has an existing accept DA.



registration states originally accepted by MDA1 and MDA3, plus those originally accepted by MDA2 and having an accept timestamp greater than T2.

#### 4.7. Anti-entropy

Anti-entropy is used for exchanging initial registration states when two peers recognize each other for the first time, and for updating new registration states after failures.

When an MDA receives an AntiEtrpRqst from a peer, it sends the requested new registration states in the increasing order of their accept IDs. At last a Service Acknowledgment (SrvAck) message is sent to indicate that the processing of a corresponding AntiEtrpRqst has been completed (Figure 9). A new registration state is sent as a fresh SrvReg with its remaining lifetime. A newly deregistered state is propagated as a SrvDeReg. Note that multiple Srv(De)Reg(s) can be sent as one TCP stream for efficiency.

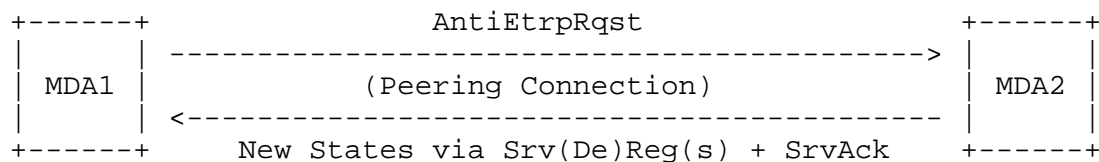


Figure 9. Anti-entropy via AntiEtrpRqst, Srv(De)Reg(s) and SrvAck

#### 4.8. Direct Forwarding

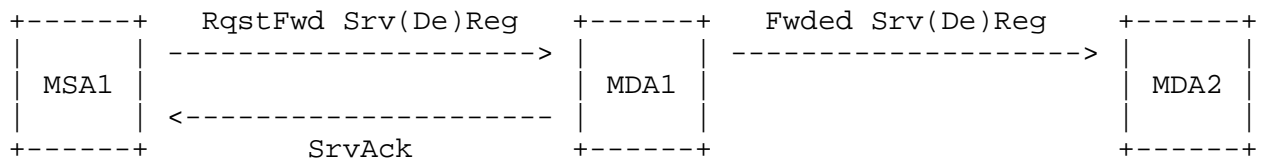


Figure 10. Direct forwarding of a Srv(De)Reg

After sending all new registration states accepted by itself to a peer (via anti-entropy), an MDA directly forwards newly received registration updates from MSAs to the peer until a failure occurs.

In Figure 10, when a Srv(De)Reg is directly forwarded from MDA1 to MDA2, its Fwd-ID is set to Fwded, and its accept timestamp is set to its arrival timestamp at MDA1. Note that a direct forwarding is performed asynchronously: MDA1 can send a SrvAck to MSA1 before it forwards the Srv(De)Reg to MDA2. Also note that the direct forwarding of a Srv(De)Reg goes only one-hop from its accept DA (say, MDA1) to all MDA1's peers that are in the registration scopes.

#### 4.9. SrvAck Message

According to [RFC2608], a DA MUST reply with a SrvAck to a Srv(De)Reg when the message is received from an SA. However, an MDA SHOULD NOT reply with a SrvAck to a Srv(De)Reg if the message is received from a peer. This is for efficiency because peers exchange Srv(De)Reg messages via reliable peering connections. Note that an MDA MUST reply with a SrvAck to an AntiEtrpRqst.

#### 4.10. Control Information

For each registration entry, an MDA maintains the following control information: an accept ID (for registration propagation), a version timestamp (for registration version resolution - rejecting previous updates), and a deletion flag (deregistered or not).

For all registration entries, an MDA maintains a summary vector to reflect its received registrations so far.

### 5. Summary

mSLP extends SLPv2 with three new definitions: a new attribute - "mesh-enhanced" for DAAdvert, a new message extension - MeshFwd, and a new message type - AntiEtrpRqst.

A UA MAY prefer an MDA to a non-MDA since an MDA is more likely to reliably contain the complete set of current service registrations for the UA's scopes.

A non-MSA needs to discover and register with all DAs in its scopes. It does not use the MeshFwd extension.

A non-MDA accepts Srv(De)Reg(s) from SAs. It does not forward them.

For all MDAs, an MSA only needs to discover and register with sufficient number of them, such that they cover its scopes. It uses the MeshFwd extension when it registers with MDAs.

An MDA carries the "mesh-enhanced" attribute keyword in its DAAdvert. It maintains a peer relationship to each peer. It accepts registrations from SAs and peers, propagates registrations via anti-entropy and direct forwarding to peers.

## 6. Protocol Timing Defaults

Interval Name	Default Value	Defined in
-----	-----	-----
CONFIG_DA_KEEPLIVE	200 seconds	Section 3.4
CONFIG_DA_TIMEOUT	300 seconds	Section 3.4

## 7. IANA Considerations

The Mesh Forwarding (MeshFwd) extension ID, 0x0006, described in Section 4.3, has been assigned by IANA out of the SLP extension space (RFC 2608, Section 9.1) reserved for "optional to implement" extensions (i.e., the 0x0000-0x3FFF range).

The function-ID of the Anti-entropy Request (AntiEtrpRqst) message type, 12, described in Section 4.6, has been assigned by IANA (RFC 2608, Section 15).

## 8. Security Considerations

mSLP uses standard SLPv2 authentication. First, an MDA SHOULD authenticate other MDAs before setting up a peer relationship with them so as to prevent any malicious MDA from joining the DA mesh. Second, as a successful attack at an MDA may affect all MDAs in the DA mesh, an MDA SHOULD authenticate MSAs before accepting and forwarding their Srv(De)Reg messages to prevent illegitimate modification or elimination of service registrations. Third, as an MSA depends on the MDA with which it registers to forward its Srv(De)Reg messages, it SHOULD authenticate the MDA to avoid using a malicious MDA.

## 9. Acknowledgments

Thomas Narten, James Kempf, Mike Day, Mikael Pahmp, Ira McDonald, Qiaobing Xie and Xingang Guo provided valuable comments for this document.

## 10. References

### 10.1. Normative References

- [RFC2608] Guttman, E., Perkins, C., Veizades, J. and M. Day, "Service Location Protocol, Version 2", RFC 2608, June 1999.
- [RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, March 1997.

## 10.2. Informative References

- [RFC1771]    Rekhter, R. and T. Li, "A Border Gateway Protocol 4 (BGP-4)", RFC 1771, March 1995.
- [RFC2610]    Perkins, C. and E. Guttman, "DHCP Options for Service Location Protocol", RFC 2610, June, 1999.
- [EPID-ALGO] A. Demers, D. Greene, C. Hauser, W. Irish, J. Larson, S. Shenker, H. Sturgis, D. Swinehart and D. Terry, "Epidemic algorithms for replicated database maintenance", the sixth ACM symposium on principles of distributed computing, Vancouver, Canada, 1987.
- [UPDA-PROP] K. Petersen, M. Spreizer, D. Terry, M. Theimer and A. Demers, "Flexible update propagation for weakly consistent replication", the sixteenth ACM symposium on operating systems principles, Saint Malo, France, 1997.

## 11. Authors' Addresses

Weibin Zhao  
Department of Computer Science  
Columbia University  
1214 Amsterdam Avenue, MC 0401  
New York, NY 10027-7003

EMail: [zwb@cs.columbia.edu](mailto:zwb@cs.columbia.edu)

Henning Schulzrinne  
Department of Computer Science  
Columbia University  
1214 Amsterdam Avenue, MC 0401  
New York, NY 10027-7003

EMail: [hgs@cs.columbia.edu](mailto:hgs@cs.columbia.edu)

Erik Guttman  
Sun Microsystems  
Eichhoelzelstr. 7  
74915 Waibstadt  
Germany

EMail: [Erik.Guttman@sun.com](mailto:Erik.Guttman@sun.com)

## 12. Full Copyright Statement

Copyright (C) The Internet Society (2003). All Rights Reserved.

This document and translations of it may be copied and furnished to others, and derivative works that comment on or otherwise explain it or assist in its implementation may be prepared, copied, published and distributed, in whole or in part, without restriction of any kind, provided that the above copyright notice and this paragraph are included on all such copies and derivative works. However, this document itself may not be modified in any way, such as by removing the copyright notice or references to the Internet Society or other Internet organizations, except as needed for the purpose of developing Internet standards in which case the procedures for copyrights defined in the Internet Standards process must be followed, or as required to translate it into languages other than English.

The limited permissions granted above are perpetual and will not be revoked by the Internet Society or its successors or assigns.

This document and the information contained herein is provided on an "AS IS" basis and THE INTERNET SOCIETY AND THE INTERNET ENGINEERING TASK FORCE DISCLAIMS ALL WARRANTIES, EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO ANY WARRANTY THAT THE USE OF THE INFORMATION HEREIN WILL NOT INFRINGE ANY RIGHTS OR ANY IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE.

## Acknowledgement

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

