

Protocol Independent Multicast - Sparse Mode (PIM-SM)  
IETF Proposed Standard Requirements Analysis

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Abstract

This document provides supporting documentation to advance the Protocol Independent Multicast - Sparse Mode (PIM-SM) routing protocol from IETF Experimental status to Proposed Standard.

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## 1. Introduction

This analysis provides supporting documentation to advance the Protocol Independent Multicast - Sparse Mode (PIM-SM) routing protocol from the IETF Experimental status to Proposed Standard. PIM-SM was first published as RFC 2117 [RFC2117] in 1997 and then again as RFC 2362 [RFC2362] in 1998. The protocol was classified as Experimental in both of these documents. The PIM-SM protocol specification was then rewritten in whole in order to more fully specify the protocol. It is this new specification that is to be advanced to Proposed Standard.

## 2. RFC 1264 Requirements

Section 4.0 of RFC 1264 [RFC1264] describes the requirements for routing protocols to advance to Proposed Standard. Each requirement is listed below along with an explanation of how the requirement has been satisfied.

### 2.1. Documents Specifying the Protocol and Its Usage

The authors of the new PIM-SM specification [RFC4601] have taken considerable care to fully specify the protocol operation. It removes all known ambiguities and tries to normalize corner cases that existed in the previous specification. It has been used to provide several interoperable implementations by developers that were not authors of the specification. These implementations will be described below.

### 2.2. Management Information Base

A Management Information Base for PIM is currently specified in RFC 2934 [RFC2934]. This MIB has many implementations and has been used by network management applications for several years. Updates to this MIB to support IPv6 and other improvements based on operation experience are in progress in the PIM Working Group of the IETF.

### 2.3. Explicit Security Architecture

The new PIM Sparse-Mode protocol specification contains an extensive security section explaining its security features and limitations. Data integrity protection and groupwise data origin authentication is provided for PIM protocol messages.

## 2.4. Implementation Existence

There are at least 4 known independent implementations of the new protocol specification, and there are over 6 independent implementations of a previous version (RFC 2362) of the specification. The new specification was carefully written to be backward compatible with the old specification allowing implementations compliant with RFC 2362 to also be compliant with the new specification.

The 4 implementations of the new version are described below.

### 2.4.1. XORP

The XORP project [XORP] has an open-source implementation of PIM-SM v2 as specified in RFC 4601. It was written by Pavlin Radoslavov <pavlin@icir.org> and has been available to the public since December 2002. Pavlin is not an author of the protocol specification. It does not use any other existing code as a base.

### 2.4.2. Cisco IOS/IOX

Cisco Systems, Inc., has written an implementation of the new protocol specification that has been deployed in production routers. There exists an IOS implementation for IPv6 only. There exists an IOX implementation for both IPv4 and IPv6. This code was initially written by Isidor Kouvelas <kouvelas@cisco.com>. It does not depend on any existing code base. Isidor is a co-author of the protocol specification.

### 2.4.3. Infosys Technologies, Ltd.

Infosys Technologies, Ltd. (www.infosys.com), has developed a limited shared-tree implementation of the new Sparse-Mode specification including PIM Hello messages, DR election, PIM join/prune messages, join suppression, and prune override. It was written by Bharat Joshi <bharat\_joshi@infosys.com> and is used in commercial products. Bharat is not an author of the protocol specification.

### 2.4.4. Procket Networks

An implementation was written from scratch at Procket Networks by Dino Farinacci <dino@cisco.com>. This implementation is now owned by Cisco Systems, Inc. Dino is not an author of the new protocol specification.

## 2.5. Evidence of Testing

### 2.5.1. Cisco

The Cisco implementation has undergone extensive laboratory testing as well as testing in production deployments. It is found to interoperate with implementations of earlier versions of the PIM Sparse-Mode protocol specification.

### 2.5.2. XORP

The XORP PIM-SM implementation has been thoughtfully tested internally by the XORP project. The emphasis during testing has been on correctness. In a typical setup, a PIM-SM router's behavior is tested by connecting it to external packet generators and observers. The packet generators are used to generate messages such as IGMP and PIM-SM control packets, and multicast data packets. The packet observers are used to observe the PIM-SM control packets generated by the PIM-SM router under test, and to observe the data packets that may be forwarded by that router. In addition, the router's command-line interface has been used to observe its internal state during some of the tests.

The test scenarios have been designed to follow the protocol specification closely (e.g., a separate test has been created for each event in the various protocol state machines, etc). All test scenarios are described in detail in the XORP PIM-SM Test Suite [XORP-TEST].

The major tested features are:

1. Multicast data forwarding.
2. PIM Hello messages exchange, PIM router neighbor discovery, option exchange, and DR election.
3. PIM Register messages transmission and reception, PIM Register state machine, and multicast data packets encapsulation and decapsulation.
4. Transmission and reception of PIM Join/Prune messages and upstream and downstream protocol state machines. The tests consider the following state: (\*,\*,RP), (\*,G), (S,G), and (S,G,rpt).
5. Transmission and reception of PIM Assert messages and the per-interface (\*,G) and (S,G) Assert state machines.

6. PIM Bootstrap mechanism: transmission, reception, and forwarding of PIM Bootstrap messages (BSMs), transmission and reception of PIM Cand-RP-Adv messages, candidate and non-candidate Bootstrap Router (BSR) state machines, creating the RP-Set at the BSR, receiving and using the RP-Set, and semantic fragmentation of BSMs.

In the final tests, the tested router behaved as specified in the PIM-SM protocol specification. All issues found in the protocol specification itself have been corrected in earlier versions of the document.

#### 2.5.3. Procket Networks

The Procket Networks implementation was deployed in many research and service provider networks and showed interoperability with new and old Cisco Systems implementations as well as Juniper Networks implementations.

#### 2.6. Suitability

PIM Sparse-Mode is a protocol for efficiently routing multicast groups that may span wide-area (and inter-domain) Internets. PIM uses the underlying unicast routing to provide reverse-path information for multicast tree building, but it is not dependent on any particular unicast routing protocol.

#### 2.7. Authentication Mechanisms

PIM specifies the use of the IP security (IPsec) authentication header (AH) to provide data integrity protection and groupwise data origin authentication of protocol messages. The specific AH authentication algorithm and parameters, including the choice of authentication algorithm and the choice of key, are configured by the network administrator. The threats associated with receiving forged PIM messages are outlined in the security considerations section of the protocol specification.

### 3. Security Considerations

No considerations apply to a requirements analysis about a routing protocol, only to a specification for that routing protocol.

### 4. Acknowledgements

Pavlin Radoslavov provided text for the section on XORP testing.  
Dino Farinacci provided text for the Procket Networks testing.

## 5. References

### 5.1. Normative References

- [RFC2934] McCloghrie, K., Farinacci, D., Thaler, D., and B. Fenner, "Protocol Independent Multicast MIB for IPv4", RFC 2934, October 2000.
- [RFC4601] Fenner, B., Handley, M., Holbrook, H., and I. Kouvelas, "Protocol Independent Multicast - Sparse Mode (PIM-SM): Protocol Specification (Revised)", RFC 4601, August 2006.

### 5.2. Informative References

- [RFC1264] Hinden, R., "Internet Engineering Task Force Internet Routing Protocol Standardization Criteria", RFC 1264, October 1991.
- [RFC2117] Estrin, D., Farinacci, D., Helmy, A., Thaler, D., Deering, S., Handley, M., Jacobson, V., Liu, C., Sharma, P., and L. Wei, "Protocol Independent Multicast-Sparse Mode (PIM-SM): Protocol Specification", RFC 2117, June 1997.
- [RFC2362] Estrin, D., Farinacci, D., Helmy, A., Thaler, D., Deering, S., Handley, M., Jacobson, V., Liu, C., Sharma, P., and L. Wei, "Protocol Independent Multicast-Sparse Mode (PIM-SM): Protocol Specification", RFC 2362, June 1998.
- [XORP] "XORP Project", <<http://www.xorp.org>>.
- [XORP-TEST] "XORP PIM-SM Test Suite", <[http://www.xorp.org/releases/current/docs/pim\\_testsuite/pim\\_testsuite.pdf](http://www.xorp.org/releases/current/docs/pim_testsuite/pim_testsuite.pdf)>.

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## Acknowledgement

Funding for the RFC Editor function is provided by the IETF Administrative Support Activity (IASA).

