          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

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5.2. Informative References

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[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>.

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