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Network Working Group                                        G. Malkin
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RIP Version 2

Status of this Memo

   This document specifies an Internet standards track protocol for the
   Internet community, and requests discussion and suggestions for
   improvements. Please refer to the current edition of the "Internet
   Official Protocol Standards" (STD 1) for the standardization state
   and status of this protocol. Distribution of this memo is unlimited.

Abstract

   This document specifies an extension of the Routing Information
   Protocol (RIP), as defined in [1], to expand the amount of useful
   information carried in RIP messages and to add a measure of security.

   A companion document will define the SNMP MIB objects for RIP-2 [2].
   An additional document will define cryptographic security
   improvements for RIP-2 [3].

Acknowledgements

   I would like to thank the IETF RIP Working Group for their help in
   improving the RIP-2 protocol. Much of the text for the background
   discussions about distance vector protocols and some of the
   descriptions of the operation of RIP were taken from "Routing
   Information Protocol" by C. Hedrick [1]. Some of the final editing on
   the document was done by Scott Bradner.

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1. Justification

With the advent of OSPF and IS-IS, there are those who believe that
RIP is obsolete. While it is true that the newer IGP routing
protocols are far superior to RIP, RIP does have some advantages.
Primarily, in a small network, RIP has very little overhead in terms
of bandwidth used and configuration and management time. RIP is also
very easy to implement, especially in relation to the newer IGPs.

Additionally, there are many, many more RIP implementations in the
field than OSPF and IS-IS combined. It is likely to remain that way
for some years yet.

Given that RIP will be useful in many environments for some period of
time, it is reasonable to increase RIP's usefulness. This is
especially true since the gain is far greater than the expense of the
change.

2. Current RIP

The current RIP-1 message contains the minimal amount of information
necessary for routers to route messages through a network. It also
contains a large amount of unused space, owing to its origins.

The current RIP-1 protocol does not consider autonomous systems and
IGP/EGP interactions, subnetting [11], and authentication since
implementations of these postdate RIP-1. The lack of subnet masks is
a particularly serious problem for routers since they need a subnet
mask to know how to determine a route. If a RIP-1 route is a network
route (all non-network bits 0), the subnet mask equals the network
mask. However, if some of the non-network bits are set, the router
cannot determine the subnet mask. Worse still, the router cannot
determine if the RIP-1 route is a subnet route or a host route.
Currently, some routers simply choose the subnet mask of the
interface over which the route was learned and determine the route
type from that.

3. Basic Protocol

3.1 Introduction

RIP is a routing protocol based on the Bellman-Ford (or distance
vector) algorithm. This algorithm has been used for routing
computations in computer networks since the early days of the
ARPANET. The particular packet formats and protocol described here
are based on the program "routed," which is included with the
Berkeley distribution of Unix.

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In an international network, such as the Internet, it is very
unlikely that a single routing protocol will used for the entire
network. Rather, the network will be organized as a collection of
Autonomous Systems (AS), each of which will, in general, be
administered by a single entity. Each AS will have its own routing
technology, which may differ among AS's. The routing protocol used

within an AS is referred to as an Interior Gateway Protocol (IGP). A
separate protocol, called an Exterior Gateway Protocol (EGP), is used
to transfer routing information among the AS's. RIP was designed to
work as an IGP in moderate-size AS's. It is not intended for use in
more complex environments. For information on the context into which
RIP-1 is expected to fit, see Braden and Postel [6].

RIP uses one of a class of routing algorithms known as Distance
Vector algorithms. The earliest description of this class of
algorithms known to the author is in Ford and Fulkerson [8]. Because
of this, they are sometimes known as Ford-Fulkerson algorithms. The
term Bellman-Ford is also used, and derives from the fact that the
formulation is based on Bellman's equation [4]. The presentation in
this document is closely based on [5]. This document contains a
protocol specification. For an introduction to the mathematics of
routing algorithms, see [1]. The basic algorithms used by this
protocol were used in computer routing as early as 1969 in the
ARPANET. However, the specific ancestry of this protocol is within
the Xerox network protocols. The PUP protocols [7] used the Gateway
Information Protocol to exchange routing information. A somewhat
updated version of this protocol was adopted for the Xerox Network
Systems (XNS) architecture, with the name Routing Information
Protocol [9]. Berkeley's routed is largely the same as the Routing
Information Protocol, with XNS addresses replaced by a more general
address format capable of handling IPv4 and other types of address,
and with routing updates limited to one every 30 seconds. Because of
this similarity, the term Routing Information Protocol (or just RIP)
is used to refer to both the XNS protocol and the protocol used by
routed.

RIP is intended for use within the IP-based Internet. The Internet
is organized into a number of networks connected by special purpose
gateways known as routers. The networks may be either point-to-point
links or more complex networks such as Ethernet or token ring. Hosts
and routers are presented with IP datagrams addressed to some host.
Routing is the method by which the host or router decides where to
send the datagram. It may be able to send the datagram directly to
the destination, if that destination is on one of the networks that
are directly connected to the host or router. However, the
interesting case is when the destination is not directly reachable.

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In this case, the host or router attempts to send the datagram to a
router that is nearer the destination. The goal of a routing
protocol is very simple: It is to supply the information that is
needed to do routing.

3.2 Limitations of the Protocol

This protocol does not solve every possible routing problem. As
mentioned above, it is primary intended for use as an IGP in networks
of moderate size. In addition, the following specific limitations

are be mentioned:

- The protocol is limited to networks whose longest path (the network's diameter) is 15 hops. The designers believe that the basic protocol design is inappropriate for larger networks. Note that this statement of the limit assumes that a cost of 1 is used for each network. This is the way RIP is normally configured. If the system administrator chooses to use larger costs, the upper bound of 15 can easily become a problem.

- The protocol depends upon "counting to infinity" to resolve certain unusual situations. (This will be explained in the next section.) If the system of networks has several hundred networks, and a routing loop was formed involving all of them, the resolution of the loop would require either much time (if the frequency of routing updates were limited) or bandwidth (if updates were sent whenever changes were detected). Such a loop would consume a large amount of network bandwidth before the loop was corrected. We believe that in realistic cases, this will not be a problem except on slow lines. Even then, the problem will be fairly unusual, since various precautions are taken that should prevent these problems in most cases.

- This protocol uses fixed "metrics" to compare alternative routes. It is not appropriate for situations where routes need to be chosen based on real-time parameters such a measured delay, reliability, or load. The obvious extensions to allow metrics of this type are likely to introduce instabilities of a sort that the protocol is not designed to handle.

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3.3. Organization of this document

   The main body of this document is organized into two parts, which occupy the next two sections:

      A conceptual development and justification of distance vector algorithms in general.

      The actual protocol description.

   Each of these two sections can largely stand on its own. Section 3.4 attempts to give an informal presentation of the mathematical underpinnings of the algorithm. Note that the presentation follows a "spiral" method. An initial, fairly simple algorithm is described.

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