ROUTING CONSORTIUM

Routing Information Protocol Version 2 (RIP)
Operations Test Suite

Technical Document

Revision 4.4

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MODIFICATION RECORD

Version 4.4 Complete   August 31, 2005
                                        Added diagrams to all tests
                                        Minor formatting changes
                                        Minor grammatical changes

                                    September 1, 2005
                                        Modified diagrams
                                        Minor grammatical changes

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                                        Removed test: Subnet Mask Validation
                                        Restructured test labels

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                                        Modified test 1.7
                                        Added Part A heading on single-part tests

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                                        Reversed pass conditions for test 4.5a, based on wording in the
                                        Router Requirements RFC.

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                                        Cosmetic changes to the cover page

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INTRODUCTION

Overview

The University of New Hampshire's InterOperability Laboratory (IOL) is an institution designed to improve the interoperability of standards based products by providing an environment where a product can be tested against other implementations of a standard. This suite of tests has been developed to help implementers evaluate the functioning of their Router Information Protocol implementations. The tests do not determine if a product conforms to the specifications, nor are they purely interoperability tests. Rather, they provide a method to isolate problems within a device. Successful completion of all tests contained in this suite does not guarantee that the tested device will operate with other RIP devices. However, these tests provide a reasonable level of confidence that the Router Under Test will function well in most multi-vendor RIP environments.

Test Software

The UNH IOL Testing Software is not a full RIP implementation; it is simply a packet generator that can transmit and receive packets. This allows the Testing Node to generate invalid packets and to simulate parts of the Router Information Protocol. The Testing Software is not currently available to the public.

Acronyms

Acronyms used in this Test Suite:

> LP: **L**ink **P**artner
> N: **N**etwork
> RTE: **R**outing **T**able **E**ntry
> RUT: **R**outer **U**nder **T**est
> TR: **T**esting **R**outer

When several entities of the same type are present in a test configuration, a number is appended to the acronym to yield a label for each entity. For example, if there were three testing routers in the test configuration, they would be labeled TR1, TR2 and TR3.

TEST ORGANIZATION

This document organizes tests by group based on related test methodology or goals. Each group begins with a brief set of comments pertaining to all tests within that group. This is followed by a series of description blocks; each block describes a single test. The format of the description block is as follows:

Test Label: The test label and title comprise the first line of the test block. The test label is composed by concatenating the short test suite name, the group number, and the test number within the group, separated by periods. The Test Number is the group and test number, also separated by a period. So, test label RIP.1.2 refers to the second test of the first test group in the RIP suite. The test number is 1.2.

Purpose: The Purpose is a short statement describing what the test attempts to achieve. It is usually phrased as a simple assertion of the feature or capability to be tested.

References: The References section lists cross-references to the specifications and documentation that might be helpful in understanding and evaluating the test and results.

Discussion: The Discussion is a general discussion of the test and relevant section of the specification, including any assumptions made in the design or implementation of the test as well as known limitations.

Test Setup: The Test Setup section describes the configuration of all devices prior to the start of the test. Different parts of the procedure may involve configuration steps that deviate from what is given in the test setup. If a value is not provided for a protocol parameter, then the following Default Setup is used:

- Split Horizon/Poisoned Reverse: Enabled
- Compatibility Switch: RIP-2
- Receive Control Switch: Both RIP-1 and RIP-2
- Timeout Timer: 180 seconds
- Garbage Collection Timer: 120 seconds
- Periodic Update Timer: 30 seconds
- Triggered Responses: Enabled
- Redistribution of routes to directly connected networks: Enabled

In addition, at the end of each test in which routes could be learned, be they valid or invalid, the routes are sent with metric 16 to ensure they are deleted. Because of this, the RUT should expire any learned routes at the end of each test.

Procedure: This section of the test description contains the step-by-step instructions for carrying out the test. These steps include such things as enabling interfaces, unplugging devices from the network, or sending packet from a test station. The test procedure also cues the tester to make observations, which are interpreted in accordance with the observable results given for that test part.

**Observable
Results:**
This section lists observable results that can be examined by the tester to verify that the RUT is operating properly. When multiple observable results are possible, this section provides a short discussion on how to interpret them. The determination of a pass or fail for each test is usually based on how the RUT's behavior compares to the results described in this section.

Possible Problems:
This section contains a description of known issues with the test procedure, which may affect test results in certain situations.

REFERENCES

The following documents are referenced in this text:

- [1058] Hedrick, C. "Routing Information Protocol." STD 34. RFC 1058. Rutgers University, June 1988.

- [1812] Baker, F. "Requirements for IP Version 4 Routers." RFC 1812. Cisco Systems, June 1995.

- [2082] Baker, F. and Atkinson, R. "RIP-2 MD5 Authentication." RFC 2082. Cisco Systems, January 1997.

- [2453] Malkin, G. "RIP Version 2." STD 56. RFC 2453. November 1998

ABSTRACT

The following tests cover the operation of the Router Information Protocol (RIP). RIP specifies a distance-vectored routing protocol that dynamically finds the shortest cost path to a destination. Packets destined to use that route are then forwarded to the next hop that has the least cost. Although the RIP approach is not optimal, it takes a minimal amount of time to setup and manage. The simplicity of RIP makes it easy to implement and thus many different implementations are currently in use.

GROUP 1: Processing

Scope:

The following tests cover portions of the Routing Information Protocol associated with the processing of packets.

Overview:

These tests are designed to verify that the RUT behaves properly when processing the information of received routing update messages. The test router in this group of tests consists of an analyzer that can send and receive frames.
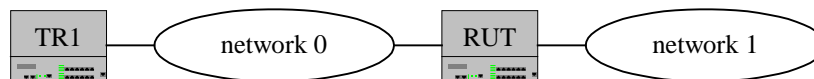
Test RIP.1.1: Basic Response Processing

Purpose: To verify that a router performs the correct processing on receipt of a properly formatted RIP Response including several route entries.

References: [2453] – Sections 3.9.2 and 3.10.1

Discussion: Once an entry has been validated, adopt the route from the datagram (i.e., put the new metric in and adjust the next hop address, if necessary).

Triggered updates do not need to include the entire routing table. In principle, only those routes which have changed need to be included. Therefore, messages generated as part of a triggered update must include at least those routes that have their route change flag set. They may include additional routes, at the discretion of the implementor; however, sending complete routing updates is strongly discouraged. When a triggered update is processed, messages should be generated for every directly-connected network. Split Horizon processing is done when generating triggered updates as well as normal updates (see section 3.9). If, after Split Horizon processing for a given network, a changed route will appear unchanged on that network (e.g., it appears with an infinite metric), the route need not be sent. If no routes need be sent on that network, the update may be omitted. Once all of the triggered updates have been generated, the route change flags should be cleared.

Test Setup: Default Setup.

Procedure:
Part A: Basic Response Processing
1. TR1 transmits a RIP Response with 3 RTEs to the All RIP-2 Routers Multicast Address.
2. Observe the packets transmitted by the RUT.
3. TR1 transmits a RIP Response for the routes learned in this test with a metric of 16.

Observable Results:
- In Part A, the RUT should transmit a triggered response to the multicast address 224.0.0.9 on each of its other interfaces advertising the learned routes. The network and subnet mask of each route should be the same as was advertised by the test software. The metrics should be calculated correctly. The next hops from the original RTEs should be learned, and included with each route in the RUT's routing table, but may be changed to indicate the RUT as next hop in the RUT's responses. The RUT should include the learned routes in its periodic responses.

Possible Problems: None.

Test RIP.1.2: Next Hop Processing

Purpose: To verify that a router behaves correctly in several cases where the next hop of a Route Entry should be considered the originator of the packet.

References: [2453] – Section 4.4
                    [2453] – Appendix A

Discussion: There are several cases in which the next hop for a Route Entry should be considered the originator of the response packet. A next hop field value of 0.0.0.0 indicates that the next hop should be the originator of the packets. Also, if the next hop is not available on any directly connected network, it should be considered the originator of the response packet.

The Next Hop field indicates the immediate next hop IP address to which packets to the destination specified by this Route Entry should be forwarded. Specifying a value of 0.0.0.0 in this field indicates that routing should be via the originator of the RIP advertisement. An address specified as a next hop must, per force, be directly reachable on the logical subnet over which the advertisement is made.

The purpose of the next hop field is to eliminate packets being routed through extra hops in the system. It is particularly useful when RIP is not being run on all of the routers on a network. A simple example is given in Appendix A. Note that next hop is an "advisory" field. That is, if the provided information is ignored, a possibly sub-optimal, but absolutely valid, route may be taken. If the received next hop is not directly reachable, it should be treated as 0.0.0.0.

Test Setup: Default Setup.
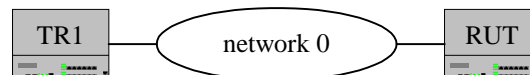
Procedure:
Part A: Next Hop specifies 0.0.0.0
1. TR1 transmits a RIP Response that includes a Route Entry. The next hop for this RTE is 0.0.0.0.
2. Observe the RUT's routing table to determine what next hop is used for the route advertised.
3. TR1 transmits a RIP Response for the routes learned in this test with a metric of 16.
Part B: Next Hop not on a Directly Connected Network
4. TR1 transmits a RIP Response that includes a Route Entry. The next hop for this RTE is not on a directly connected network.
5. Observe the RUT's routing table to determine what next hop is used for the route advertised.
6. TR1 transmits a RIP Response for the routes learned in this test with a metric of 16.
Part C: Next Hop not Directly Reachable
7. TR1 transmits a RIP Response for some network N with a next hop of TR2.
8. TR1 transmits a RIP Response that includes a Route Entry with a next hop on network N, which is not a directly connected network.
9. Observe the RUT's routing table to determine what next hop is used for the route advertised.
10. TR1 transmits a RIP Response for the routes learned in this test with a metric of 16.

Observable Results:

- In Parts A and B, the next hop should be the originator of the RIP Response.
- In Part C, the next hop should be treated as 0.0.0.0 (the originator of the RIP Response, e.g., TR1) since it is not on a directly connected network.

Possible Problems: None.

Test RIP.1.3: Subnet Mask Processing

Purpose: To verify that a router correctly interprets and processes the subnet mask field.

References: [2453] – Section 4.3

Discussion: The Subnet Mask field contains the subnet mask which is applied to the IP address to yield the non-host portion of the address. If this field is zero, then no subnet mask has been included for this entry.

On an interface where a RIP-1 router may hear and operate on the information in a RIP-2 routing entry the following rules apply:

1)   information internal to one network must never be advertised into another network,
2)   information about a more specific subnet may not be advertised where RIP-1 routers would consider it a host route, and
3)   supernet routes (routes with a netmask less specific than the "natural" network mask) must not be advertised where they could be misinterpreted by RIP-1 routers.

Test Setup: Default Setup.
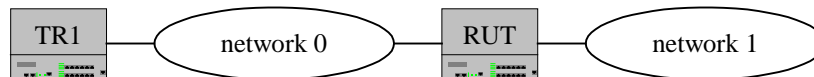
Procedure:
Part A: Subnet Mask Processing
1.   TR1 transmits a RIP Response with 3 RTEs. Each RTE has a subnet mask value of 0.0.0.0. There is one entry each for a Class A, Class B, and Class C network.
2.   Observe the packets transmitted by the RUT.
3.   TR1 transmits a RIP Response for the routes learned in this test with a metric of 16.

Observable Results:
•   In Part A, the triggered response transmitted by the RUT on its other interfaces should include the newly learned routes with subnet mask values appropriate to the natural network number.

Possible Problems: If the RUT does not include the generated subnet mask value in its response packets, it will be necessary to check the routing table to verify the results.

Test RIP.1.4: Default Route Processing

Purpose: To verify that a router learns default routes.

References: [1812] – Section 5.2.4.3
                    [2453] – Section 3.7

Discussion: The special address 0.0.0.0 is used to describe a default route. A default route is defined as a route to all networks for which there are no explicit routes. It is by definition the route whose prefix length is zero. A default route is used when it is not convenient to list every possible network in the RIP updates, and when one or more closely-connected routers in the system are prepared to handle traffic to the networks that are not listed explicitly. These routers should create RIP entries for the address 0.0.0.0, just as if it were a network to which they are connected. The decision as to how routers create entries for 0.0.0.0 is left to the implementor. Most commonly, the system administrator will be provided with a way to specify which routers should create entries for 0.0.0.0; however, other mechanisms are possible. For example, an implementor might decide that any router which speaks BGP should be declared to be a default router. It may be useful to allow the network administrator to choose the metric to be used in these entries. If there is more than one default router, this will make it possible to express a preference for one over the other. The entries for 0.0.0.0 are handled by RIP in exactly the same manner as if there were an actual network with this address. System administrators should take care to make sure that routes to 0.0.0.0 do not propagate further than is intended. Generally, each autonomous system has its own preferred default router. Thus, routes involving 0.0.0.0 should generally not leave the boundary of an autonomous system. The mechanisms for enforcing this are not specified in this document.

Test Setup: Default Setup.

Procedure:
Part A: No Subnet Mask Provided
1. TR1 transmits a RIP Response with one RTE indicating a default route. The subnet mask value is 0.0.0.0.
2. Observe the packets transmitted by the RUT.
3. TR1 transmits a RIP Response for the routes learned in this test with a metric of 16.
Part B: Subnet Mask Provided
4. TR1 transmits a RIP Response with one RTE indicating a default route. The subnet mask value is 255.255.255.0.
5. Observe the packets transmitted by the RUT.
6. TR1 transmits a RIP Response for the routes learned in this test with a metric of 16.
Part C: Default Route Updated
7. TR1 transmits a RIP Response with one RTE indicating a default route.
8. TR2 transmits a RIP Response with one RTE indicating a default route.
9. Observe the packets transmitted by the RUT and the RUT's routing table.
10. TR1 and TR2 transmit RIP Responses for the routes learned in this test with a metric of 16.

Part D: Default Route Originated Correctly
    11. Configure a default route on the RUT.
    12. Observe the packets transmitted by the RUT and the RUT's routing table.

Observable Results:
- In Part A, the RUT should transmit a triggered response advertising the default route.
- In Part B, the RUT should not crash or generate invalid packets.
- In Part C, the default route should not be present twice in any RIP Responses sent by the RUT.
- In Part D, the RUT should propagate the default route as 0.0.0.0 with a subnet mask of 0 bits.

Possible Problems: None.

Test RIP.1.5: Infinite Metric Processing

Purpose: To verify that a router behaves properly when the metric calculated for a route is 16.

References: [2453] – Section 3.9.2

Discussion: Once the entry has been validated, update the metric by adding the cost of the network on which the message arrived. If the result is greater than infinity, use infinity. That is,

metric = MIN (metric + cost, infinity)

Now, check to see whether there is already an explicit route for the destination address. If there is no such route, add this route to the routing table, unless the metric is infinity (there is no point in adding a route which is unusable).

Test Setup: Default Setup.
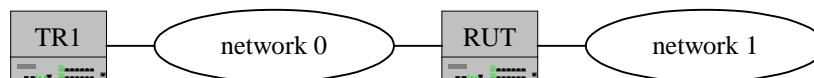
Procedure:
Part A: Metric Recalculated to 16
1. TR1 transmits a RIP Response including a Route Entry with metric 1.
2. TR1 transmits a RIP Response with two RTEs. One RTE gives the route advertised in Step 1 with metric 15, the other gives a route that is not in the RUT's table, with metric 15.
3. Observe the packets transmitted by the RUT.
4. TR1 transmits a RIP Response for the routes learned in this test with a metric of 16.
Part B: Metric Recalculated to greater than 16
5. Set the metric for one of the interfaces on the RUT to 2.
6. TR1 transmits a RIP Response including a Route Entry with metric 1 to the interface in Step 5.
7. TR1 transmits a RIP Response with two RTEs. One RTE gives the route advertised in Step 6 with metric 15, the other gives a route that is not in the RUT's table, with metric 15.
8. Observe the packets transmitted by the RUT.
9. TR1 transmits a RIP Response for the routes learned in this test with a metric of 16.

Observable Results:
- In Part A, the RUT should transmit a triggered response giving the route that it learned in Step 1 with the newly calculated metric of 16. The other route present in the response transmitted in Step 2 should not be present in any response transmitted by the RUT.
- In Part B, the RUT should transmit a triggered response giving the route that it learned in Step 6 with the newly calculated metric of 16. The other route present in the response transmitted in Step 7 should not be present in any response transmitted by the RUT.

Possible Problems: None.

Test RIP.1.6: Host Route Processing

Purpose: To verify that a router identifies and processes host routes correctly.

References: [2453] – Section 3.7

Discussion: If every node on a given network or subnet is accessible through the same routers, then there is no reason to mention individual hosts in the routing tables. However, networks that include point-to-point lines sometimes require routers to keep track of routes to certain nodes. Whether this feature is required depends upon the addressing and routing approach used in the system. Thus, some implementations may choose not to support host routes. If host routes are not supported, they are to be dropped when they are received in response messages

Test Setup: Default Setup.
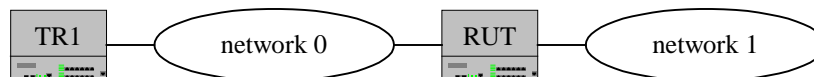
Procedure:
Part A: Router Accepts Host Routes
1. TR1 transmits a RIP Response including a host route.
2. Observe the packets transmitted by the RUT.
3. TR1 transmits a RIP Response for the routes learned in this test with a metric of 16.
Part B: Router does not Accept Host Routes
4. Configure the RUT to not accept Host Routes.
5. TR1 transmits a RIP Response including a host route followed by a valid route.
6. Observe the packets transmitted by the RUT.
7. TR1 transmits a RIP Response for the routes learned in this test with a metric of 16.

Observable Results:
- In Part A, the RUT should have learned the host route from the RIP Response, and should transmit a triggered response advertising it.
- In Part B, the RUT should not have learned the host route from the RIP Response. The valid route that follows should be processed normally. Host routes should not be present in any RIP Responses transmitted by the RUT.

Possible Problems: None.

Test RIP.1.7: Version Number Processing

Purpose: To verify that a router obeys the rules for processing RIP messages of versions other than 2.

References: [2453] – Section 3.10.2, 4.6, and 5.1

Discussion: Before processing the datagrams in detail, certain general format checks must be made. These depend upon the version number field in the datagram, as follows:

   0   Datagrams whose version number is zero are to be ignored. These are from a previous version of the protocol, whose packet format was machine-specific.

   1   Datagrams whose version number is one are to be processed as described in the rest of this specification. All fields that are described above as "must be zero" are to be checked. If any such field contains a non-zero value, the entire message is to be ignored.

   >1 Datagrams whose version number is greater than one are to be processed as described in the rest of this specification. All fields that are described above as "must be zero" are to be ignored. Future versions of the protocol may put data into these fields. Version 1 implementations are to ignore this extra data and process only the fields specified in this document.

When generating RIP Responses, set the version number to either 1 or 2. The mechanism for deciding which version to send is implementation specific; however, if this is the Response to a Request, the Response version should match the Request version.

In addition, routers should also implement a receive control switch which would determine whether to accept RIP-1 only, RIP-2 only, both, or none. It should also be configurable on a per-interface basis. It is recommended that the default be compatible with the default chosen for sending updates. If the receive control switch is set to both, a router should not accept a route whose version is other than 1 or 2.

Test Setup: Default Setup.

| TR1 | network 0 | RUT | network 1 |
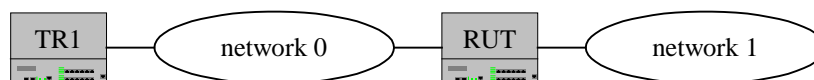
Procedure:
Part A: Version 1 RIP Response
   1. TR1 transmits a RIP version 1 Response including a Route Entry for some network.
   2. Observe the packets transmitted by the RUT.
   3. TR1 transmits a RIP Response for the routes learned in this test with a metric of 16.
Part B: Version 0 RIP Response
   4. TR1 transmits a RIP version 0 Response including a Route Entry for some network.
   5. Observe the packets transmitted by the RUT.
   6. TR1 transmits a RIP Response for the routes learned in this test with a metric of 16.

Part C: Version 1 RIP Request
7. Configure the RUT to send out RIP-1 messages.
8. TR1 transmits a RIP version 1 Request including a Route Entry the RUT does not have.
9. Observe the packets transmitted by the RUT.

Part D: Version 2 RIP Request
10. Configure the RUT to send out RIP-2 messages.
11. TR1 transmits a RIP version 2 Request including a Route Entry the RUT does not have.
12. Observe the packets transmitted by the RUT.

Observable Results:
- In Part A, the RUT should have learned the version 1 route advertised.
- In Part B, the RUT should not have learned the version 0 routes advertised.
- In Part C, the RUT should respond with a RIP version 1 Response including the Route Entry with metric 16.
- In Part D, the RUT should respond with a RIP version 2 Response including the Route Entry with metric 16.

Possible Problems: None.

Test RIP.1.8: Family Identifier Processing

Purpose: To verify that a router properly handles RIP Responses that contain RTEs with Address Family Identifiers other than 2.

References: [2453] – Sections 3.6 and 3.9.2

Discussion: For each of these message types, in version 1, the remainder of the datagram contains a list of Route Entries (RTEs). Each RTE in this list contains an Address Family Identifier (AFI), destination IPv4 address, and the cost to reach that destination (metric).

The AFI is the type of address. For RIP-1, only AF_INET (2) is generally supported.

Once the datagram as a whole has been validated, process the RTEs in the Response one by one. Again, start by doing validation. Incorrect metrics and other format errors usually indicate misbehaving neighbors and should probably be brought to the administrator's attention. For example, if the metric is greater than infinity, ignore the entry but log the event. The basic validation tests are:

- is the destination address valid (e.g., unicast; not net 0 or 127)
- is the metric valid (i.e., between 1 and 16, inclusive)

If any check fails, ignore that entry and proceed to the next. Again, logging the error is probably a good idea.

Test Setup: Default Setup.
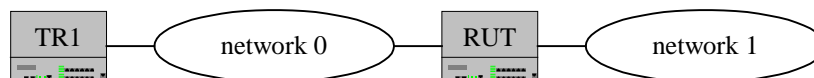
Procedure:
Part A: Family Identifier Processing
1. TR1 transmits a RIP Response with one RTE that has the Address Family Identifier set to something other than 2.
2. TR1 transmits a RIP Response that has a mix of RTEs, one with Address Family Identifier 2, the others with Address Family Identifier set to something other than 2.
3. Observe the packets transmitted by the RUT.
4. TR1 transmits a RIP Response for the routes learned in this test with a metric of 16.

Observable Results:
- In Part A, the only new route the RUT should have is the route with Address Family Identifier 2. The RUT should learn no other new routes during this test.

Possible Problems: None.

Test RIP.1.9: Route Tags Processing

**Purpose:**   To verify that a router properly learns and re-advertises route tags.

References: [2453] – Section 4.2

Discussion: The Route Tag (RT) field is an attribute assigned to a route which must be preserved and readvertised with a route. The intended use of the Route Tag is to provide a method of separating "internal" RIP routes (routes for networks within the RIP routing domain) from "external" RIP routes, which may have been imported from an EGP or another IGP.

Routers supporting protocols other than RIP should be configurable to allow the Route Tag to be configured for routes imported from different sources. For example, routes imported from EGP or BGP should be able to have their Route Tag either set to an arbitrary value, or at least to the number of the Autonomous System from which the routes were learned.

Other uses of the Route Tag are valid, as long as all routers in the RIP domain use it consistently. This allows for the possibility of a BGP-RIP protocol interactions document, which would describe methods for synchronizing routing in a transit network.

Test Setup: Default Setup.
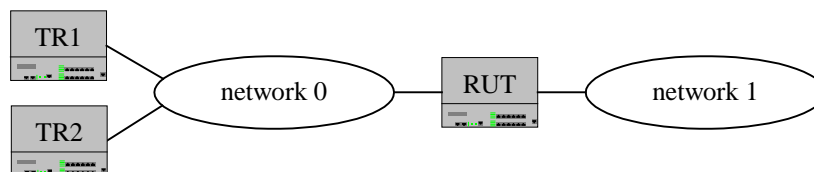
Procedure:
Part A: RUT Preserves Route Tags
1.   TR1 transmits a RIP Response including several RTEs, each with a different route tag.
2.   Observe the packets transmitted by the RUT.
3.   TR1 transmits a RIP Response for the routes learned in this test with a metric of 16.
Part B: RUT Preserves Route Tags in Updated RTEs
4.   TR1 transmits a RIP Response including 2 RTEs, each with a route tag.
5.   TR2 transmits a RIP Response for route 1, but with a lower metric and a different route tag.
6.   Allow route 2 to expire, and then transmit a response from the same router used in Step 4, but with a different route tag.
7.   Observe the packets transmitted by the RUT.
8.   TR1 transmits a RIP Response for the routes learned in this test with a metric of 16.

Observable Results:
*   In Part A, the RUT should send out the routes advertised in a triggered response, and the route tag for each route should be included unchanged.
*   In Part B, both routes should use the route tag from the most recent response.

Possible Problems: None.

Test RIP.1.10: Triggered Response Processing

Purpose: To verify that a router observes the rules regarding triggered responses.

References: [2453] – Section 3.10.1, 3.10.2

Discussion: Experience shows that triggered updates can cause excessive load on networks with limited capacity or networks with many routers on them. Therefore, the protocol requires that implementors include provisions to limit the frequency of triggered updates. After a triggered update is sent, a timer should be set for a random interval between 1 and 5 seconds. If other changes that would trigger updates occur before the timer expires, a single update is triggered when the timer expires. The timer is then reset to another random value between 1 and 5 seconds. A triggered update should be suppressed if a regular update is due by the time the triggered update would be sent.

Triggered updates do not need to include the entire routing table. In principle, only those routes which have changed need to be included. Therefore, messages generated as part of a triggered update must include at least those routes that have their route change flag set. They may include additional routes, at the discretion of the implementor; however, sending complete routing updates is strongly discouraged. When a triggered update is processed, messages should be generated for every directly-connected network. Split Horizon processing is done when generating triggered updates as well as normal updates (see section 3.9). If, after Split Horizon processing for a given network, a changed route will appear unchanged on that network (e.g., it appears with an infinite metric), the route need not be sent. If no routes need be sent on that network, the update may be omitted. Once all of the triggered updates have been generated, the route change flags should be cleared.

The only difference between a triggered update and other update messages is the possible omission of routes that have not changed. The remaining mechanisms must be applied to all updates.

Test Setup: Default Setup.
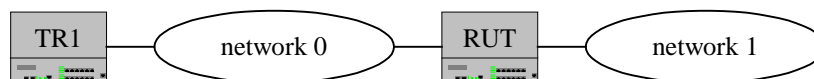
Procedure:
Part A: Triggered Response Only Includes Updated Routes
1. TR1 transmits a RIP Response including several routes.
2. TR1 transmits another RIP Response, giving a subset of the routes advertised in the first step with a higher metric.
3. Observe the packets transmitted by the RUT.
4. TR1 transmits a RIP Response for the routes learned in this test with a metric of 16.
Part B: Rate of Triggered Responses Limited
5. TR1 transmits a RIP Response giving a route with metric 1. Every second thereafter, increment the metric and transmit the response packet again. Transmit the response a total of ten times.
6. Observe the packets transmitted by the RUT.
7. TR1 transmits a RIP Response for the routes learned in this test with a metric of 16.

Observable Results:

- In Part A, Step 2, the RUT should have sent a triggered response to all networks except the network to which TR1 is connected. The triggered response should include only the routes that changed as a result of the response sent in the previous step. The RUT should not transmit a triggered response on the network to which TR1 is connected, as no routes had changed due to split horizon/poisoned reverse processing.
- In Part B, the RUT should wait a random interval from 1 to 5 seconds between transmitting triggered responses.

Possible Problems: None.

Test RIP.1.11: Route Timeout Processing

Purpose: To verify that a router performs route timeout correctly.

References: [2453] – Section 3.8, 3.9.2

Discussion: There are two timers associated with each route, a "timeout" and a "garbage-collection" time. Upon expiration of the timeout, the route is no longer valid; however, it is retained in the routing table for a short time so that neighbors can be notified that the route has been dropped. Upon expiration of the garbage-collection timer, the route is finally removed from the routing table.

The timeout is initialized when a route is established, and any time an update message is received for the route. If 180 seconds elapse from the last time the timeout was initialized, the route is considered to have expired, and the deletion process described below begins for that route.

Deletions can occur for one of two reasons: the timeout expires, or the metric is set to 16 because of an update received from the current router (see section 3.7.2 for a discussion of processing updates from other routers). In either case, the following events happen:

- The garbage-collection timer is set for 120 seconds.
- The metric for the route is set to 16 (infinity). This causes the route to be removed from service.
- The route change flag is set to indicate that this entry has been changed.
- The output process is signaled to trigger a response.

Until the garbage-collection timer expires, the route is included in all updates sent by this router. When the garbage-collection timer expires, the route is deleted from the routing table.

Should a new route to this network be established while the garbage-collection timer is running, the new route will replace the one that is about to be deleted. In this case the garbage-collection timer must be cleared.

Note that the deletion process is started only when the metric is first set to infinity. If the metric was already infinity, then a new deletion process is not started.

Test Setup: Default Setup.
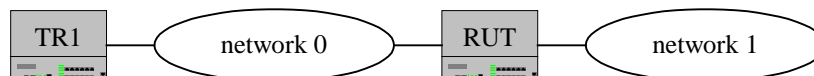
Procedure:
Part A: Route Deleted Due to Update or Timeout
1. TR1 transmits a RIP Response including RTEs for two routes.
2. TR1 transmits a RIP Response for one of the routes given in Step 1 with a metric of 16.
3. Wait more than 300 seconds and observe the packets transmitted by the RUT.

Part B: Timeout Timer Restarted When Route Updated
    4. TR1 transmits a RIP Response including a RTE for 1 route.
    5. Wait 60 seconds.
    6. TR1 transmits a RIP Response including the RTE sent in Step 4.
    7. Wait more than 300 seconds and observe the packets transmitted by the RUT.
Part C: Garbage-Collection Timer Stopped When Route Updated
    8. TR1 transmits a RIP Response including a RTE for 1 route.
    9. Wait 240 seconds.
    10. TR1 transmits a RIP Response including the RTE sent in Step 8.
    11. Wait more than 300 seconds and observe the packets transmitted by the RUT.
Part D: Deletion Process not Restarted
    12. TR1 transmits a RIP Response including a RTE for 1 route.
    13. TR1 transmits a RIP Response including the RTE sent in Step 12 with a metric of 16.
    14. Wait 60 seconds.
    15. TR1 transmits a RIP Response including the RTE sent in Step 12 with a metric of 16.
    16. Wait more than 120 seconds and observe the packets transmitted by the RUT.

Observable Results:
- In Part A, the RUT should transmit a triggered response for the route that was expired after the RIP Response in Step 2 is received. It should also be included in periodic responses with metric 16 for 120 seconds after its expiration. The route that was not updated by Step 2 should expire after 180 seconds from Step 1 and be included in periodic RIP Responses with metric 16 for 120 seconds.
- In Part B, Step 5, the RUT should advertise the learned route for 60 seconds. In Step 6, the timeout timer for the entry created in Step 4 should be restarted. In Step 7, the RUT should advertise the learned route with the appropriate metric for 180 seconds from when the RIP Response was transmitted in Step 6. The RUT should then advertise the learned route with a metric of 16 for 120 seconds.
- In Part C, Step 9, the RUT should advertise the learned route for 180 seconds. The RUT should then advertise the learned route with a metric of 16 for 60 seconds. In Step 10, the timeout timer should be restarted and the garbage-collection timer stopped. In Step 11, the RUT should advertise the learned route for 180 seconds from when the RIP Response was transmitted in Step 10. The RUT should then advertise the learned route with a metric of 16 for 120 seconds.
- In Part D, Step 13, the RUT should send a triggered response for the deleted route. In Step 14, the RUT should include the deleted route with a metric of 16 in its periodic updates. In Step 15, the RUT should not restart the garbage-collection timer. In Step 16, the RUT should only include the deleted route with a metric of 16 in its periodic updates for 60 additional seconds.

Possible Problems: None.

Test RIP.1.12: Number of Entries Processing

Purpose: To verify that a router handles responses that contains an unusual number of RTEs.

References: [2453] – Sections 3.9.1 and 3.10.2

Discussion: This section describes how a Response message is generated for a particular directly connected network:

Set the version number to either 1 or 2. The mechanism for deciding which version to send is implementation specific; however, if this is the Response to a Request, the Response version should match the Request version. Set the command to Response. Set the bytes labeled "must be zero" to zero. Start filling in RTEs. Recall that there is a limit of 25 RTEs to a Response; if there are more, send the current Response and start a new one. There is no defined limit to the number of datagrams which make up a Response.

A Request is used to ask for a response containing all or part of a router's routing table. A Request is processed entry by entry. If there are no entries, no response is given. There is one special case. If there is exactly one entry in the request, and it has an address family identifier of zero and a metric of infinity (i.e., 16), then this is a request to send the entire routing table. In that case, a call is made to the output process to send the routing table to the requesting address/port. Except for this special case, processing is quite simple. Examine the list of RTEs in the Request one by one. For each entry, look up the destination in the router's routing database and, if there is a route, put that route's metric in the metric field of the RTE. If there is no explicit route to the specified destination, put infinity in the metric field. Once all the entries have been filled in, change the command from Request to Response and send the datagram back to the requestor.

Test Setup: Default Setup.
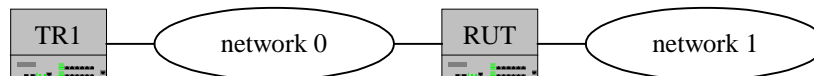
Procedure:
Part A: RIP Response with no RTEs
    1.   TR1 transmits a RIP Response with no RTEs.
    2.   Observe the packets transmitted by the RUT.
Part B: RIP Request with no RTEs
    3.   TR1 transmits a RIP Request with no RTEs.
    4.   Observe the packets transmitted by the RUT.
Part C: Maximum Size Message Received
    5.   TR1 transmits a RIP Response with 25 valid RTEs.
    6.   TR1 transmits a RIP Request with the 25 valid RTEs given in Step 5.
    7.   Observe the packets transmitted by the RUT.
    8.   TR1 transmits a RIP Response for the routes learned in this test with a metric of 16.

Part D: More than 25 Entries Sent in Multiple Responses
9. TR1 transmits two RIP Responses, each with 20 valid RTEs.
10. Observe the packets transmitted by the RUT.
11. TR1 transmits a RIP Response for the routes learned in this test with a metric of 16.

Observable Results:
- In Part A, the empty response should not cause the RUT to generate any packets.
- In Part B, the empty request should not cause the RUT to generate any packets.
- In Part C, Step 5, the RUT should process the response with 25 routes as normal. All of the routes from the test packet should be added and should be present in the RUT's triggered response. In Step 6, the RUT should respond to the RIP Request with all 25 RTEs in one RIP Response.
- In Part D, the RUT should transmit multiple RIP Responses each containing a subset of its routing information for that network.

Possible Problems: None.

Test RIP.1.13: Compatibility with v1 Switches Processing

Purpose: To verify that a router behaves properly in each of the modes described for the v1 compatibility switch.

**References:**   [2453] – Section 4.6, 5.1

Discussion: A compatibility switch is necessary for two reasons. First, there are implementations of RIP-1 in the field which do not follow RFC [1] (RFC-1058). Second, the use of multicasting would prevent RIP-1 systems from receiving RIP-2 updates (which may be a desired feature in some cases). This switch should be configurable on a per-interface basis.

The switch has four settings: RIP-1, in which only RIP-1 messages are sent; RIP-1 compatibility, in which RIP-2 messages are broadcast; RIP-2, in which RIP-2 messages are multicast; and "none", which disables the sending of RIP messages. It is recommended that the default setting be either RIP-1 or RIP-2, but not RIP-1 compatibility. This is because of the potential problems which can occur on some topologies. RIP-1 compatibility should only be used when all of the consequences of its use are well understood by the network administrator.

For completeness, routers should also implement a receive control switch which would determine whether to accept RIP-1 only, RIP-2 only, both, or none. It should also be configurable on a per-interface basis. It is recommended that the default be compatible with the default chosen for sending updates.

If a RIP-2 router receives a RIP-1 Request, it should respond with a RIP-1 Response. If the router is configured to send only RIP-2 messages, it should not respond to a RIP-1 Request.

Test Setup: Default Setup.
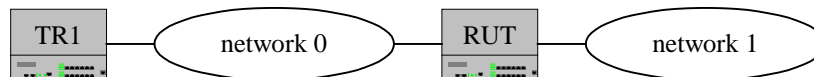
Procedure:
Part A: Compatibility Switch
1. Configure the RUT to operate in RIP-1 Mode. Wait for the RUT to transmit a periodic response.
2. Observe the packets transmitted by the RUT.
3. Configure the RUT to operate in RIP-1 Compatible Mode. Wait for the RUT to transmit a periodic response.
4. Observe the packets transmitted by the RUT.
5. Configure the RUT to operate in RIP-2 mode. Wait for the RUT to transmit a periodic response.
6. Observe the packets transmitted by the RUT.

Part B: Receive Control Switch Accepts RIP-1 Only
7. Configure the RUT to accept only RIP-1 messages. Also configure the RUT to send out RIP-1 messages.
8. TR1 transmits a RIP version 2 Request for a Route Entry the RUT does not have.
9. TR1 transmits a RIP version 2 Response with a Route Entry.
10. TR1 transmits a RIP version 1 Request for a Route Entry the RUT does not have.
11. TR1 transmits a RIP version 1 Response with a Route Entry.
12. Observe the packets transmitted by the RUT.
13. TR1 transmits a RIP Response for the routes learned in this test with a metric of 16.

Part C: Receive Control Switch Accepts RIP-2 Only
14. Configure the RUT to accept only RIP-2 messages. Also configure the RUT to send out RIP-2 messages.
15. TR1 transmits a RIP version 2 Request for a Route Entry the RUT does not have.
16. TR1 transmits a RIP version 2 Response with a Route Entry.
17. TR1 transmits a RIP version 1 Request for a Route Entry the RUT does not have.
18. TR1 transmits a RIP version 1 Response with a Route Entry.
19. Observe the packets transmitted by the RUT.
20. TR1 transmits a RIP Response for the routes learned in this test with a metric of 16.

Part D: Receive Control Switch Accepts Both RIP-1 and RIP-2
21. Configure the RUT to accept both RIP-1 and RIP-2 messages. Also configure the RUT to send out RIP-2 messages.
22. TR1 transmits a RIP version 2 Request for a Route Entry the RUT does not have.
23. TR1 transmits a RIP version 2 Response with a Route Entry.
24. TR1 transmits a RIP version 1 Request for a Route Entry the RUT does not have.
25. TR1 transmits a RIP version 1 Response with a Route Entry.
26. Observe the packets transmitted by the RUT.
27. TR1 transmits a RIP Response for the routes learned in this test with a metric of 16.

Observable Results:
- In Part A, Step 1, the RUT should transmit RIP-1 Response Packets to the Subnet Broadcast Address. In Step 3, the RUT should transmit RIP-2 Response Packets to the Subnet Broadcast Address. In Step 5, the RUT should transmit RIP-2 Response Packets to the All RIP-2 Router Multicast Address.
- In Part B, Steps 8 and 9, the RUT should ignore the version 2 messages. In Steps 10 and 11, the RUT should process the version 1 messages normally.
- In Part C, Steps 15 and 16, the RUT should process the version 2 messages normally. In Steps 17 and 18, the RUT should ignore the version 1 messages.
- In Part D, Steps 22 and 23, the RUT should process the version 2 messages normally. In Step 24, the RUT should not respond to the RIP-1 Request. In Step 25, the RUT should process the version 1 message normally.

Possible Problems: None.

Test RIP.1.14: Full Table Request Processing

Purpose: To verify that a router responds properly to full table RIP Requests.

References: [2453] – Section 3.9.1

Discussion: A Request is used to ask for a response containing all or part of a router's routing table. Normally, Requests are sent as broadcasts (multicasts for RIP-2), from the RIP port, by routers which have just come up and are seeking to fill in their routing tables as quickly as possible. However, there may be situations (e.g., router monitoring) where the routing table of only a single router is needed. In this case, the Request should be sent directly to that router from a UDP port other than the RIP port. If such a Request is received, the router responds directly to the requestor's address and port.

The Request is processed entry by entry. If there are no entries, no response is given. There is one special case. If there is exactly one entry in the request, and it has an address family identifier of zero and a metric of infinity (i.e., 16), then this is a request to send the entire routing table. In that case, a call is made to the output process to send the routing table to the requesting address/port.

If the request is for a complete routing table, normal output processing is done, including Split Horizon.

Test Setup: Default Setup.

Procedure:
Part A: Full Table Request Processing
1. TR1 transmits a RIP Response including a valid RTE.
2. TR1 transmits a RIP Response including a different valid RTE.
3. TR1 transmits a full table request on network 0.
4. TR1 transmits a full table request on network 1.
5. Observe the packets transmitted by the RUT.
6. TR1 and TR1 transmit RIP Responses for the routes learned in this test with a metric of 16.

Observable Results:
- In Part A, Step 3, the RUT should transmit response packets, including all of its learned and configured routes. Split-horizon/poisoned reverse processing should be performed on the responses.

Possible Problems: None.

Test RIP.1.15: Specific Route Request Processing

Purpose: To verify that a router responds properly to specific RIP Requests.

References: [2453] – Section 3.9.1

Discussion: Note that there is a difference in metric handling for specific and whole-table requests. If the request is for a complete routing table, normal output processing is done, including Split Horizon (see section 3.9 on Split Horizon). If the request is for specific entries, they are looked up in the routing table and the information is returned as is; no Split Horizon processing is done. It is assumed that a Request for specific networks is made only by diagnostic software, and is not used for routing. In this case, the requester would want to know the exact contents of the routing table and would not want any information hidden or modified.

Test Setup: Default Setup.
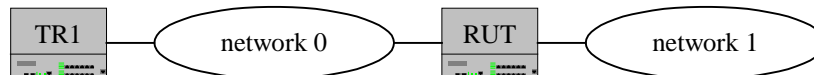
Procedure:
Part A: RIP Request sent Multicast
1.   TR1 transmits a RIP Response including one RTE.
2.   TR1 transmits another RIP Response with a single RTE to the RUT's other interface.
3.   TR1 transmits a specific multicast RIP Request for the RTEs given in the first two steps, as well as another route that the RUT does not have.
4.   Observe the packets transmitted by the RUT.
5.   TR1 transmits a RIP Response for the routes learned in this test with a metric of 16.
Part B: RIP Request sent Unicast
6.   TR1 transmits a RIP Response including one RTE.
7.   TR1 transmits another RIP Response with a single RTE to the RUT's other interface.
8.   TR1 transmits a specific unicast RIP Request for the RTEs given in the first two steps, as well as another route that the RUT does not have.
9.   Observe the packets transmitted by the RUT.
10. TR1 transmits a RIP Response for the routes learned in this test with a metric of 16.

Observable Results:
- In Parts A and B, in Steps 3 and 6, the RUT should transmit a response for the routes requested, filling in their metrics from its routing table. For the route that is not in its table a metric of 16 should be given. No Split-horizon/poisoned reverse processing should be done on this response; metrics should be given exactly as they are in the RUT's table.

Possible Problems: None.

Test RIP.1.16: Simple Authentication Processing

Purpose: To verify that a router properly processes a RIP authentication entry.

References: [2453] – Sections 4.1 and 5.2

Discussion: Since authentication is a per message function, and since there is only one 2-octet field available in the message header, and since any reasonable authentication scheme will require more than two octets, the authentication scheme for RIP version 2 will use the space of an entire RIP entry. If the Address Family Identifier of the first (and only the first) entry in the message is 0xFFFF, then the remainder of the entry contains the authentication. This means that there can be, at most, 24 RIP entries in the remainder of the message. If authentication is not in use, then no entries in the message should have an Address Family Identifier of 0xFFFF. Currently, the only Authentication Type is simple password and it is type 2. The remaining 16 octets contain the plain text password. If the password is under 16 octets, it must be left-justified and padded to the right with nulls (0x00).

The following algorithm should be used to authenticate a RIP message. If the router is not configured to authenticate RIP-2 messages, then RIP-1 and unauthenticated RIP-2 messages will be accepted; authenticated RIP-2 messages shall be discarded. If the router is configured to authenticate RIP-2 messages, then RIP-1 messages and RIP-2 messages which pass authentication shall be accepted; unauthenticated and failed authentication RIP-2 messages shall be discarded. For maximum security, RIP-1 messages should be ignored when authentication is in use (see section 4.1); otherwise, the routing information from authenticated messages will be propagated by RIP-1 routers in an unauthenticated manner.

Since an authentication entry is marked with an Address Family Identifier of 0xFFFF, a RIP-1 system would ignore this entry since it would belong to an address family other than IP. It should be noted, therefore, that use of authentication does not prevent RIP-1 systems from seeing RIP-2 messages. If desired, this may be done using multicasting, as described in sections 4.5 and 5.1.

Test Setup: Default Setup.
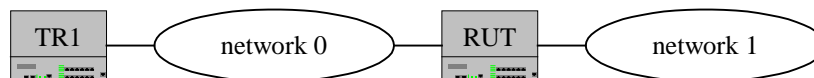
Procedure:
Part A: RUT Not Configured for Authentication
1. Configure the RUT not to perform RIP-2 authentication.
2. TR1 transmits a RIP Response with an authentication entry and a Route Entry.
3. Observe the packets transmitted by the RUT.
4. TR1 transmits a RIP Response for the routes learned in this test with a metric of 16.

Part B: RUT Receives Authentication Header with Correct Password
5. Configure the RUT to perform RIP-2 authentication, with password ABCDEFGHIJKL.
6. TR1 transmits a RIP Response with an authentication header (with the correct password) and a Route Entry.
7. Observe the packets transmitted by the RUT.
8. TR1 transmits a RIP Response for the routes learned in this test with a metric of 16.

Part C: RUT Receives Authentication Header with Incorrect Password
9. Configure the RUT to perform RIP-2 authentication, with password ABCDEFGHIJKL.
10. TR1 transmits a RIP Response with an authentication header (with an incorrect password) and a Route Entry.
11. Observe the packets transmitted by the RUT.
12. TR1 transmits a RIP Response for the routes learned in this test with a metric of 16.

Part D: RUT Configured for Authentication, Receives No Authentication Header
13. Configure the RUT to perform RIP-2 authentication, with password ABCDEFGHIJKL.
14. TR1 transmits a RIP Response with no authentication header and one Route Entry.
15. Observe the packets transmitted by the RUT.
16. TR1 transmits a RIP Response for the routes learned in this test with a metric of 16.

Part E: RUT Configured for Authentication, Receives Two Authentication Headers
17. Configure the RUT to perform RIP-2 authentication, with password ABCDEFGHIJKL.
18. TR1 transmits a RIP Response with two authentication headers and one Route Entry.
19. Observe the packets transmitted by the RUT.
20. TR1 transmits a RIP Response for the routes learned in this test with a metric of 16.

Observable Results:
- In Part A, the RUT should ignore the response packet because it has an authentication entry. The RUT should not learn the route from this packet.
- In Part B, the RUT should learn the route advertised in the RIP packet.
- In Parts C and D, the RUT should not learn the Route Entry in the RIP packets.
- In Part E, the RUT should not crash or generate invalid packets. The RUT may process the Route Entry in the RIP Response sent in Step 18.

Possible Problems: The specification is not explicit about how a device should handle the reception of two authentication headers.

Test RIP.1.17: UDP Port Processing

Purpose: To verify that a router transmits the correct source and destination UDP ports in RIP packets and only processes RIP packets sent to the RIP-1/RIP-2 port.

References: [2453] – Section 3.6, 3.9.2

Discussion: RIP is a UDP-based protocol. Each router that uses RIP has a routing process that sends and receives datagrams on UDP port number 520, the RIP-1/RIP-2 port. All communications intended for another router's RIP process are sent to the RIP port. All routing update messages are sent from the RIP port. Thus, unsolicited routing update messages have both the source and destination port equal to the RIP port. Update messages sent in response to a request are sent to the port on which the request arrived. Specific queries may be sent from ports other than the RIP port, but they must be directed to the RIP port on the target machine. Because processing of a Response may update the router's routing table, a Response must be checked carefully for validity. The Response must be ignored if it is not from the RIP port.

Test Setup: Default Setup.
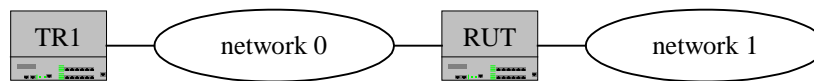
Procedure:
Part A: RIP Requests
1. TR1 transmits a specific RIP Request for a route that the RUT does not have, from UDP port 300 and to UDP port 520.
2. TR1 transmits a specific RIP Request for a route that the RUT does not have, from UDP port 521 and to UDP port 520.
3. TR1 transmits a specific RIP Request for a route that the RUT does not have, from UDP port 520 and to UDP port 300.
4. Observe the packets transmitted by the RUT.
Part B: RIP Responses
5. Wait for a periodic RIP Response from the RUT.
6. TR1 transmits a RIP Response with a route that the RUT does not have, from UDP port 300 and to UDP port 520.
7. TR1 transmits a RIP Response with a route that the RUT does not have, from UDP port 521 and to UDP port 520.
8. TR1 transmits a RIP Response with a route that the RUT does not have, from UDP port 520 and to UDP port 300.
9. Observe the packets transmitted by the RUT.

Observable Results:
- In Part A, Step 1, the RUT should transmit a RIP Response for the route specified with a metric of 16, to UDP port 300 from UDP port 520. In Step 2, the RUT should transmit a RIP Response for the route specified with a metric of 16, to UDP port 521 from UDP port 520. In Step 3, the RUT should not respond to the RIP Request sent to a UDP port that is not 520.
- In Part B, Step 5, the RUT should transmit a RIP Response to and from UDP port 520. In Steps 6 through 8, the RUT should not learn the Route Entry in the RIP packet.

Possible Problems: None.

Test RIP.1.18: Heuristic for RIP Response Processing

Purpose: To verify that a router uses the heuristic for selecting between two routers advertising the same route with the same metric.

References: [2453] – Section 3.9.2

Discussion: In a RIP Response which contains a RTE which already exists, there is a heuristic which could be applied. Normally, it is senseless to replace a route if the new route has the same metric as the existing route; this would cause the route to bounce back and forth, which would generate an intolerable number of triggered updates. However, if the existing route is showing signs of timing out, it may be better to switch to an equally-good alternative route immediately, rather than waiting for the timeout to happen. Therefore, if the new metric is the same as the old one, examine the timeout for the existing route. If it is at least halfway to the expiration point, switch to the new route. This heuristic is optional, but highly recommended.

Test Setup: Default Setup.

TR1	network 0	RUT	network 1	TR2

Procedure:
Part A: Route Entry less than halfway to Timeout
1.   TR1 transmits a RIP Response containing a Route Entry with a metric of 5.
2.   Wait 30 seconds.
3.   TR2 transmits a RIP Response containing the same Route Entry in Step 1 with a metric of 5.
4.   Observe the packets transmitted by the RUT.
5.   TR1 and TR2 transmit RIP Responses for the routes learned in this test with a metric of 16.
Part B: Route Entry more than halfway to Timeout
6.   TR1 transmits a RIP Response containing a Route Entry with a metric of 5.
7.   Wait 90 seconds.
8.   TR2 transmits a RIP Response containing the same Route Entry in Step 6 with a metric of 5.
9.   Observe the packets transmitted by the RUT.
10. TR1 and TR2 transmit RIP Responses for the routes learned in this test with a metric of 16.

Observable Results:
*   In Part A, Step 3, the RUT should not update the Route Entry specifying TR2 as the next hop.
*   In Part B, Step 8, the RUT should update the Route Entry specifying TR2 as the next hop.

Possible Problems: The RUT could learn and use both routes as a load-balancing mechanism.

Test RIP.1.19: Metric Processing

Purpose: To verify that a router properly handles RTEs that are not better than the current route for that network.

References: [2453] – Section 3.9.2

Discussion: Once an entry has been validated, update the metric by adding the cost of the network on which the message arrived. Now, check to see whether there is already an explicit route for the destination address. If there is an existing route, compare the next hop address to the address of the router from which the datagram came. If this datagram is from the same router as the existing route, reinitialize the timeout. Next, compare the metrics. If the datagram is from the same router as the existing route, and the new metric is different than the old one; or, if the new metric is lower than the old one; do the following actions:

-   Adopt the route from the datagram (i.e., put the new metric in and adjust the next hop address, if necessary).
-   Set the route change flag and signal the output process to trigger an update
-   If the new metric is infinity, start the deletion process (described above); otherwise, re-initialize the timeout

Any received RTE (from a different router than the one who sent the existing route) that is already configured on a router is ignored if it does not have a better metric, as it is no better than the current route.

Test Setup: Default Setup.

TR1 — network 0 — RUT — network 1 — TR2

Procedure:
Part A: Inferior Route Entry sent from Different Router
1. TR1 transmits a RIP Response containing a Route Entry with a metric of 6.
2. TR2 transmits a RIP Response containing the same Route Entry in Step 1 with a metric of 7.
3. Observe the packets transmitted by the RUT.
4. TR1 and TR2 transmit RIP Responses for the routes learned in this test with a metric of 16.
Part B: Inferior Route Entry sent from Same Router
5. TR1 transmits a RIP Response containing a Route Entry with a metric of 6.
6. TR1 transmits a RIP Response containing the same Route Entry in Step 5 with a metric of 7.
7. Observe the packets transmitted by the RUT.
8. TR1 and TR2 transmit RIP Responses for the routes learned in this test with a metric of 16.

Observable Results:
- In Part A, Step 2, the RUT should not update the Route Entry specifying TR2 as the next hop.
- In Part B, Step 6, the RUT should transmit a triggered RIP Response for the Route Entry with metric 8.

Possible Problems: None.

Test RIP.1.20: Static Route Processing

Purpose: To verify that a router properly handles static routes with the RIP protocol.

References: [2453] – Section 3.5

Discussion: Implementers may choose to allow the system administrator to enter additional routes. These would most likely be routes to hosts or networks outside the scope of the routing system. They are referred to as "static routes." Entries for destinations other than these initial ones are added and updated by routing algorithms. Because the RIP specification is not explicit regarding the behavior of the protocol in regards to static routes, this test is informational only.

Test Setup: Default Setup.
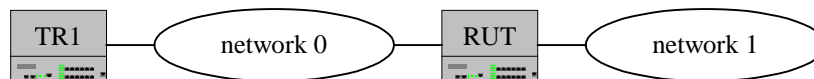
Procedure:
Part A: RUT Propagates Static Routes
1. Configure a static route on one of the interfaces on the RUT. If necessary, configure the RUT to export static routes through RIP.
2. Observe the packets transmitted by the RUT.

Part B: Static Routes not Expired Due to Timeout
3. Allow the static route from Part A to remain configured.
4. Wait more than 300 seconds.
5. Observe the packets transmitted by the RUT.

Part C: Static Routes not Expired Due to Receiving Infinite Metric
6. Configure a static route for network 133.178.119.0 on one of the interfaces on the RUT.
7. TR1 transmits a RIP Response containing a Route Entry for the static route configured in Step 6 with a metric of 16.
8. Observe the packets transmitted by the RUT.

Observable Results:
- In Part A, the RUT should propagate the static route in its periodic RIP Responses.
- In Parts B and C, the RUT should not expire or delete the static route.

Possible Problems: The specification is not explicit regarding the propagation of static routes via RIP.

GROUP 2: Validation

Scope:

The following tests cover portions of the Routing Information Protocol associated with the validation of packets.

Overview:

These tests are designed to verify that the RUT detects and handles invalid routing update messages and route entries. The test router in this group of tests consists of an analyzer that can send and receive frames.

Test RIP.2.1: Network Validation

Purpose: To verify that a router ignores RTEs for invalid networks.
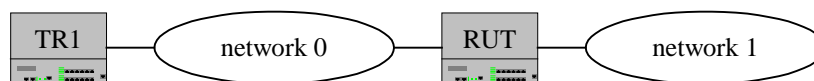
References: [2453] – Section 3.9.2

Discussion: Once the datagram as a whole has been validated, process the RTEs in the Response one by one. Again, start by doing validation. Incorrect metrics and other format errors usually indicate misbehaving neighbors and should probably be brought to the administrator's attention. For example, if the metric is greater than infinity, ignore the entry but log the event. The basic validation tests are:

-   is the destination address valid (e.g., unicast; not net 0 or 127)
-   is the metric valid (i.e., between 1 and 16, inclusive)

If any check fails, ignore that entry and proceed to the next. Again, logging the error is probably a good idea.

Test Setup: Default Setup.

Procedure:
Part A: Invalid Networks
1. TR1 transmits a RIP Response with an entry for a Class D network address followed by a valid entry.
2. TR1 transmits a RIP Response with an entry for a Class E network address followed by a valid entry.
3. TR1 transmits a RIP Response with an entry for the network 0.0.0.1 followed by a valid entry.
4. TR1 transmits a RIP Response with an entry for the network all 1s network followed by a valid entry.
5. TR1 transmits a RIP Response with an entry for the loopback network address followed by a valid entry.
6. TR1 transmits a RIP Response with an entry for the loopback host address followed by a valid entry.
7. TR1 transmits a RIP Response with an entry for the subnet broadcast address followed by a valid entry.
8. Observe the packets transmitted by the RUT.
9. TR1 transmits a RIP Response for the routes learned in this test with a metric of 16.

Part B: Invalid Networks – Interfaces on the RUT
10. TR1 transmits a RIP Response with an entry for the network of the RUT's interface followed by a valid entry.
11. TR1 transmits a RIP Response for the host address of the RUT's interface followed by a valid entry.
12. TR1 transmits a RIP Response for the network of the RUT's other interface followed by a valid entry.
13. Observe the packets transmitted by the RUT.
14. TR1 transmits a RIP Response for the routes learned in this test with a metric of 16.

Observable Results:
- In Parts A and B, the RUT should have added none of the invalid routes advertised in the test. The valid routes that follow should be processed normally.

Possible Problems: None.

Test RIP.2.2: Metric Validation

Purpose: To verify that a router correctly handles invalid values of the metric field in the RTE.
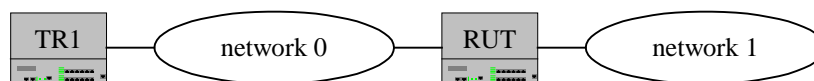
References: [2453] – Section 3.9.2

Discussion: Once the datagram as a whole has been validated, process the RTEs in the Response one by one. Again, start by doing validation. Incorrect metrics and other format errors usually indicate misbehaving neighbors and should probably be brought to the administrator's attention. For example, if the metric is greater than infinity, ignore the entry but log the event. The basic validation tests are:

- is the destination address valid (e.g., unicast; not net 0 or 127)
- is the metric valid (i.e., between 1 and 16, inclusive)

If any check fails, ignore that entry and proceed to the next. Again, logging the error is probably a good idea.

Test Setup: Default Setup.

Procedure:
Part A: Metric Validation
1. TR1 transmits a RIP Response containing a Route Entry for network 1 with metric 5.
2. TR1 transmits a RIP Response containing a Route Entry for network 1 with metric 17, followed by a valid Route Entry.
3. TR1 transmits a RIP Response containing a Route Entry with metric -1, followed by a valid Route Entry.
4. Observe the packets transmitted by the RUT.
5. TR1 transmits a RIP Response for the routes learned in this test with a metric of 16.

Observable Results:
- In Part A, Step 2, the RUT should neither expire the RTE for network 1 nor set the metric to 16. The RUT should have added none of the routes with invalid metrics advertised in the test. The valid routes that follow should be processed normally.

Possible Problems: None.

Test RIP.2.3: Must Be Zero Fields Validation

Purpose: To verify that a router discards RIP-1 packets that have data in the "must be zero" fields defined for that version of RIP.

References: [2453] – Sections 3.6 and 5

Discussion: RFC-1058 showed considerable forethought in its specification of the handling of version numbers. It specifies that RIP messages of version 0 are to be discarded, that RIP messages of version 1 are to be discarded if any Must Be Zero (MBZ) field is non-zero, and that RIP messages of any version greater than 1 should not be discarded simply because an MBZ field contains a value other than zero. This means that the new version of RIP is totally backwards compatible with existing RIP implementations which adhere to this part of the specification.

Test Setup: Default Setup.
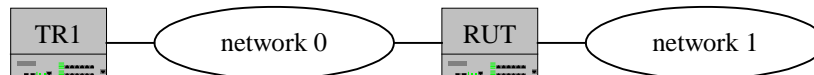
Procedure:
Part A: Must Be Zero Fields Validation
1. TR1 transmits a RIP-1 packet with data in the unused header field, with a valid RTE, followed by another valid RTE.
2. TR1 transmits a RIP-1 packet with data in the route tag field of a RTE, followed by a valid RTE.
3. TR1 transmits a RIP-1 packet with data in the next hop field of a RTE, followed by a valid RTE.
4. TR1 transmits a RIP-1 packet with data in the subnet mask field of a RTE, followed by a valid RTE.
5. Observe the packets transmitted by the RUT.
6. TR1 transmits a RIP Response for the routes learned in this test with a metric of 16.

Observable Results:
- In Part A, the RUT should have added none of the routes advertised in the test.

Possible Problems: None.
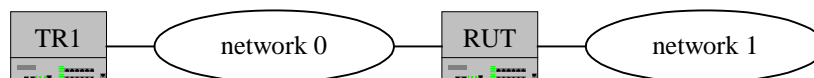
Test RIP.2.4: Command Number Validation

Purpose: To verify that a router ignores RIP packets with invalid commands.

References: [1058] – Section 3.1

Discussion: Every datagram contains a command, a version number, and possible arguments. This document describes version 1 of the protocol. Details of processing the version number are described in section 3.4. The command field is used to specify the purpose of this datagram. Here is a summary of the commands implemented in version 1:

1 - Request   A request for the responding system to send all or part of its routing table.
2 - Response   A message containing all or part of the sender's routing table. This message may be sent in response to a request or poll, or it may be an update message generated by the sender.
3 - Traceon   Obsolete. Messages containing this command are to be ignored.
4 - Traceoff   Obsolete. Messages containing this command are to be ignored.
5 - Reserved   This value is used by Sun Microsystems for its own purposes. If new commands are added in any succeeding version, they should begin with 6. Messages containing this command may safely be ignored by implementations that do not choose to respond to it.

Test Setup: Default Setup.

Procedure:
Part A: Command Number Validation
1. TR1 transmits a RIP Traceon, including a Route Entry as would be expected in a RIP Response.
2. TR1 transmits a RIP Traceoff, including a Route Entry as would be expected in a RIP Response.
3. TR1 transmits a RIP packet with an unknown command number, including a Route Entry as would be expected in a RIP Response.
4. Observe the packets transmitted by the RUT.
5. TR1 transmits a RIP Response for the routes learned in this test with a metric of 16.

Observable Results:
- In Part A, the RUT should ignore the commands in this test and should not add any new routes.

Possible Problems: None.

Test RIP.2.5: Invalid Number of Entries Validation

Purpose: To verify that a router does not encounter an error on receipt of a RIP Response with more than 25 entries.

References: [2453] – Section 3.6

Discussion: There may be between 1 and 25 (inclusive) Route Entries. Although not explicitly stated in the standard, the receipt of RIP Request or RIP Response with more than 25 Route Entries should not cause a router to crash or generate invalid packets.

Test Setup: Default Setup.
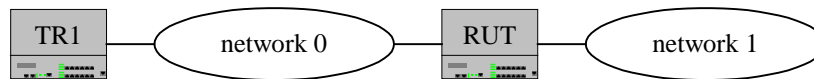
Procedure:
Part A: Invalid Number of Entries Validation
1. TR1 transmits a RIP version 2 Response with more than 25 RTEs.
2. TR1 transmits a RIP version 1 Response with more than 25 RTEs.
3. TR1 transmits a RIP version 2 Request with more than 25 RTEs.
4. TR1 transmits a RIP version 1 Request with more than 25 RTEs.
5. Observe the packets transmitted by the RUT.
6. TR1 transmits a RIP Response for the routes learned in this test with a metric of 16.

Observable Results:
- In Part A, the RUT should not crash or generate invalid packets as a result of receiving a RIP Response or Request that contains too many RTEs.

Possible Problems: None.

Test RIP.2.6: Source Address Validation

Purpose: To verify that a router checks RIP Responses for validity with regards to the source IP address.

References: [2453] – Section 3.9.2

Discussion: Because processing of a RIP Response may update the router's routing table, the Response must be checked carefully for validity. The datagram's IPv4 source address should be checked to see whether the datagram is from a valid neighbor; the source of the datagram must be on a directly-connected network. It is also worth checking to see whether the response is from one of the router's own addresses. Interfaces on broadcast networks may receive copies of their own broadcasts/multicasts immediately. If a router processes its own output as new input, confusion is likely, so such datagrams must be ignored.

Test Setup: Default Setup.

TR1 — network 0 — RUT — network 1
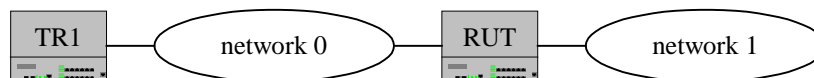
Procedure:
Part A: Source Address Validation
1. TR1 transmits a RIP Response with a source IP address equal to the loopback address, and a Route Entry.
2. TR1 transmits a RIP Response with a source IP address that is multicast, and a Route Entry.
3. Transmit a RIP Response with a source IP address that is not on the directly connected network, and a Route Entry.
4. TR1 transmits a RIP Response with a source IP address the same as the RUT's receiving interface, and a Route Entry.
5. TR1 transmits a RIP Response with a source IP address the same as the RUT's interface on another network, and a Route Entry.
6. Observe the packets transmitted by the RUT.
7. TR1 transmits a RIP Response for the routes learned in this test with a metric of 16.

Observable Results:
- In Part A, the RUT should not have learned any of the routes advertised because all of the Response packets have invalid source addresses.

Possible Problems: None.

Test RIP.2.7: Next Hop Validation

Purpose: To verify that a router checks RIP Responses for validity with regards to the next hop field in Route Entries.

References: [2453] - Section 4.4

Discussion: The immediate next hop IP address to which packets to the destination specified by this Route Entry should be forwarded. Specifying a value of 0.0.0.0 in this field indicates that routing should be via the originator of the RIP advertisement. An address specified as a next hop must, per force, be directly reachable on the logical subnet over which the advertisement is made. The purpose of the Next Hop field is to eliminate packets being routed through extra hops in the system. It is particularly useful when RIP is not being run on all of the routers on a network. A simple example is given in Appendix A of RFC 2453. Note that Next Hop is an "advisory" field. That is, if the provided information is ignored, a possibly sub-optimal, but absolutely valid, route may be taken. If the received Next Hop is not directly reachable, it should be treated as 0.0.0.0.

Test Setup: Default Setup.
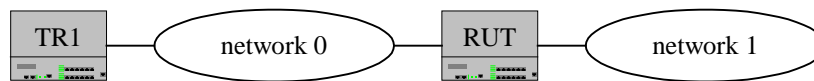
Procedure:
Part A: Next Hop Validation
1. TR1 transmits a RIP Response with a Route Entry that gives the loopback address as Next Hop.
2. TR1 transmits a RIP Response with a Route Entry that gives a multicast address as Next Hop.
3. TR1 transmits a RIP Response with a Route Entry that gives the address of the RUT's receiving interface as Next Hop.
4. TR1 transmits a RIP Response with a Route Entry that gives the address of the RUT's interface on another network as Next Hop.
5. Observe the packets transmitted by the RUT.
6. TR1 transmits a RIP Response for the routes learned in this test with a metric of 16.

Observable Results:
• In Part A, the RUT should either ignore the RTEs with invalid Next Hops or accept the RTEs and use a Next Hop of the TR that sent the RIP Responses in Step 1 through 4.

Possible Problems: The specification does not require a router to verify validity of the Next Hop field.

GROUP 3: Forwarding

Scope:

The following tests cover portions of the Routing Information Protocol associated with the forwarding of packets.

Overview:

These tests are designed to verify conformance with the Routing Information Protocol specifications.

Test RIP.3.1: Basic Forwarding

Purpose: To verify that a router can perform basic forwarding functions.

References: [1812] – Section 5.2.1.2

Discussion: This is a test of basic forwarding function, using Network, Host and Default routes. When a router receives a packet to be forwarded, if the destination is an IP unicast address, the forwarder determines the next hop IP address for the packet, usually by looking up the packet's destination in the router's routing table. A router's routing table is determined by static routes and by routing protocols such as RIP.

Test Setup: Default Setup.
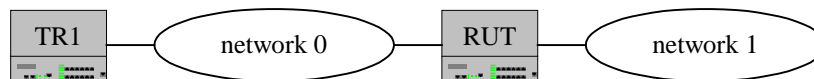
Procedure:
Part A: Basic Forwarding
1. TR1 transmits a RIP Response with 3 RTEs: one network route, one host route, and one default route.
2. TR1 transmits an ICMP Echo Request destined for the host given in the host route.
3. TR1 transmits an ICMP Echo Request destined for the network given in the network route.
4. TR1 transmits an ICMP Echo Request destined for a network the RUT has no specific route for.
5. Observe the packets transmitted by the RUT.
6. TR1 transmits a RIP Response for the routes learned in this test with a metric of 16.

Observable Results:
*   In Part A, Step 2, the ICMP Echo Request should be forwarded to the next hop given for the host route. In Step 3, the ICMP Echo Request should be forwarded to the next hop given for the network route. In Step 4, the ICMP Echo Request should be forwarded to the next hop given for the default route.

Possible Problems: None.

Test RIP.3.2: Priority Forwarding

Purpose: To verify that a router prefers the best available route when forwarding.

References: [1812] – Section 5.2.1.2

Discussion: When a router receives a packet to be forwarded, if the destination is an IP unicast address, the forwarder determines the next hop IP address for the packet, usually by looking up the packet's destination in the router's routing table. A router's routing table is determined by static routes and by routing protocols such as RIP. When multiple routes could be used to route a particular packet, the one that is the longest match with the destination address should be chosen. If more than one route is the same length match, the route's metric is used to break the tie.

Test Setup: Default Setup.
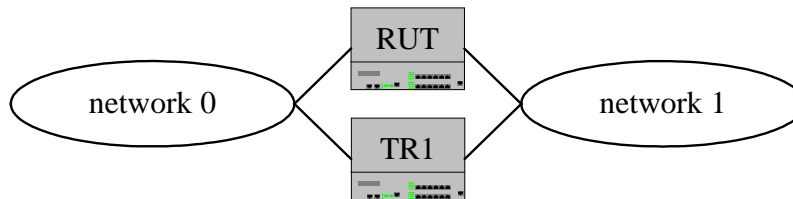
Procedure:
Part A: Priority Forwarding
1. TR1 transmits a RIP Response containing a default route.
2. TR1 transmits an ICMP Echo Request for some destination on network 1.
3. TR1 transmits a RIP Response advertising a natural network route network 1. Network 1 is subnetted.
4. TR1 transmits an ICMP Echo Request for some destination on network 1.
5. TR1 transmits a RIP Response advertising a natural network route network 1, with a lower metric than in the third step.
6. TR1 transmits an ICMP Echo Request for some destination on network 1.
7. TR1 transmits a RIP Response for a subnetted network route for network 1.
8. TR1 transmits an ICMP Echo Request for some destination on network 1.
9. TR1 transmits a RIP Response for a subnetted network route for network 1, with a lower metric than in the seventh step.
10. TR1 transmits an ICMP Echo Request for some destination on network 1.
11. Observe the packets transmitted by the RUT.
12. TR1 transmits a RIP Response for the routes learned in this test with a metric of 16.

Observable Results:
- In Part A, each ICMP Echo Request should be forwarded to the next hop specified in the most recently transmitted response packet, because each response packet gives a better route to the destination network of the ICMP Echo Requests.

Possible Problems: None.

Test RIP.3.3: Expired Route

Purpose: To verify that a router does not use an expired route for forwarding.

References: [1812] – Section 5.2.1.2
[2453] - Section 3.8

Discussion: When a router receives a packet to be forwarded, if the destination is an IP unicast address, the forwarder determines the next hop IP address for the packet, usually by looking up the packet's destination in the router's routing table. A router's routing table is determined by static routes and by routing protocols such as RIP. In RIP, there are two timers associated with each route, a "timeout" and a "garbage-collection" time. Upon expiration of the timeout, the route is no longer valid; however, it is retained in the routing table for a short time so that neighbors can be notified that the route has been dropped. When evaluating a valid RIP Response with an RTE already present in the routing table, a router compares the metrics. If the new metric is infinity, start the deletion process (described above). A route that is no longer valid is not used for forwarding packets.

Test Setup: Default Setup.
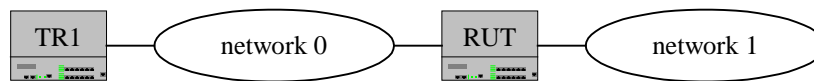
Procedure:
Part A: Route Deleted Due to Timeout
1. TR1 transmits a RIP Response containing a default route.
2. Wait 180 seconds.
3. TR1 transmits an ICMP Echo Request for some destination on network 1.
4. Observe the packets transmitted by the RUT.
5. TR1 transmits a RIP Response for the routes learned in this test with a metric of 16.
Part B: Route Deleted Due to Update
6. TR1 transmits a RIP Response containing a default route.
7. TR1 transmits a RIP Response containing the route sent in Step 6 with a Metric of 16.
8. TR1 transmits an ICMP Echo Request for some destination on network 1.
9. Observe the packets transmitted by the RUT.

Observable Results:
- In Part A, the ICMP Echo Request sent in Step 3 should not be forwarded to the next hop of TR1, as the route is no longer valid.
- In Part B, the ICMP Echo Request sent in Step 8 should not be forwarded to the next hop of TR1, as the route is no longer valid.

Possible Problems: None.

GROUP 4: MD5 Authentication

Scope:

The following tests cover portions of the Routing Information Protocol that involve authentication of RIP messages by the MD5 algorithm.

Overview:

These tests are designed to verify that the RUT properly handles authentication using the MD5 algorithm. These tests should only be run if the RUT supports MD5 authentication. Unless otherwise specified, the Key ID remains the same throughout the test. The test router in this group of tests consists of an analyzer that can send and receive frames.

Test RIP.4.1: Basic MD5 Authentication

Purpose: To verify that a router can perform basic MD5 authentication processing functionality.

References: [2082] – Section 3

Discussion: When a message is received:

(1) The digest is set aside,
(2) The appropriate algorithm and key are determined from the value of the Key Identifier field,
(3) The RIP-2 Authentication Key is written into the appropriate number (16 when Keyed MD5 is used) of bytes starting at the offset indicated,
(4) Appropriate padding is added as needed, and
(5) A new digest calculated using the indicated algorithm.

If the calculated digest does not match the received digest, the message is discarded unprocessed.

Test Setup: Default Setup.
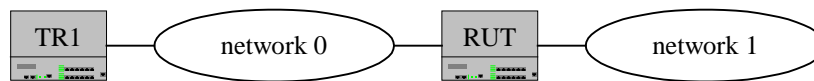
Procedure:
Part A: RUT Not Configured for Authentication
1. Configure the RUT not to perform MD5 authentication.
2. TR1 transmits a RIP Response with a correct authentication header and a Route Entry.
3. Observe the packets transmitted by the RUT.
4. TR1 transmits a RIP Response for the routes learned in this test with a metric of 16.
Part B: RUT Receives Authentication Header with Correct Digest
5. Configure the RUT to perform MD5 authentication, with a secret of ABCDEFGHIJKL (0x4142434445464748494A4B4C).
6. TR1 transmits a RIP Response with an authentication header (correct digest) and a Route Entry.
7. Observe the packets transmitted by the RUT.
8. TR1 transmits a RIP Response for the routes learned in this test with a metric of 16.
Part C: RUT Configured for Authentication, Receives Un-Authenticated RIP Message
9. Configure the RUT to perform MD5 authentication, with a secret of ABCDEFGHIJKL (0x4142434445464748494A4B4C).
10. TR1 transmits a RIP Response with no authentication header and one Route Entry.
11. Observe the packets transmitted by the RUT.
12. TR1 transmits a RIP Response for the routes learned in this test with a metric of 16.

Observable Results:

- In Part A, the RUT should ignore the response packet because it has an MD5 authentication entry. The RUT should not learn the route from this packet.
- In Part B, the RUT should learn the route advertised in the RIP packet.
- In Part C, the RUT should not learn the Route Entry in the RIP packet.

Possible Problems: None.

Test RIP.4.2: Incorrect Digest

**Purpose:**   To verify that a router does not accept RIP messages with MD5 authentication using an incorrect digest.

References: [2082] – Section 3

Discussion: When a message is received:

(1) The digest is set aside,
(2) The appropriate algorithm and key are determined from the value of the Key Identifier field,
(3) The RIP-2 Authentication Key is written into the appropriate number (16 when Keyed MD5 is used) of bytes starting at the offset indicated,
(4) Appropriate padding is added as needed, and
(5) A new digest calculated using the indicated algorithm.

If the calculated digest does not match the received digest, the message is discarded unprocessed.

Test Setup: Default Setup.
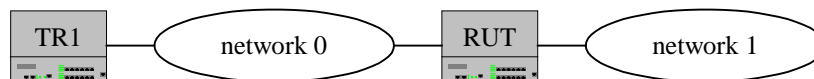
Procedure:
Part A: Incorrect Key ID
1. Configure the RUT to perform MD5 authentication, with two different keys (Key IDs 1 and 2) on a single interface. Key ID 1 should have a secret of ABCDEFGHIJKL (0x4142434445464748494A4B4C), and Key ID 2 should have a secret of MNOPQRSTUVWX (0x4D4E4F505152535455565758).
2. TR1 transmits a RIP Response with a properly formatted authentication header for Key ID 1, but with the digest for Key ID 2. The RIP Response should also include a Route Entry.
3. Observe the packets transmitted by the RUT.
4. TR1 transmits a RIP Response for the routes learned in this test with a metric of 16.
Part B: Incremented Incorrect Digest
5. Configure the RUT to perform MD5 authentication, with a secret of ABCDEFGHIJKL (0x4142434445464748494A4B4C).
6. TR1 transmits a RIP Response with an authentication header, an incorrect digest formed by incrementing the correct digest by one, and a Route Entry.
7. Observe the packets transmitted by the RUT.
8. TR1 transmits a RIP Response for the routes learned in this test with a metric of 16.

Part C: Zero Digest
9. Configure the RUT to perform MD5 authentication, with a secret of ABCDEFGHIJKL (0x4142434445464748494A4B4C).
10. TR1 transmits a RIP Response with an authentication header, an incorrect digest of all zeros, and a Route Entry.
11. Observe the packets transmitted by the RUT.
12. TR1 transmits a RIP Response for the routes learned in this test with a metric of 16.

Part D: Highest Digest
13. Configure the RUT to perform MD5 authentication, with a secret of ABCDEFGHIJKL (0x4142434445464748494A4B4C).
14. TR1 transmits a RIP Response with an authentication header, an incorrect digest of all ones binary, and a Route Entry.
15. Observe the packets transmitted by the RUT.
16. TR1 transmits a RIP Response for the routes learned in this test with a metric of 16.

Observable Results:
- In all Parts, the RUT should ignore the response message because the MD5 authentication digest is incorrect. The RUT should not learn the route from this packet.

Possible Problems: None.

Test RIP.4.3: Sequence Numbers

Purpose: To verify that a router handles sequence numbers properly.
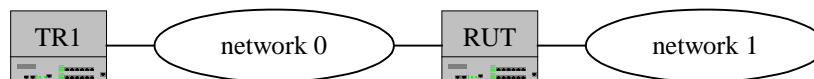
References: [2082] – Section 3.1, 3.2.2

Discussion: MD5 authentication includes the use of an unsigned 32 bit sequence number. The sequence number MUST be non-decreasing for all messages sent with the same Key ID. If the neighbor has been heard from recently enough to have viable routes in the route table and the received sequence number is less than the last one received, the message likewise is discarded unprocessed. When connectivity to the neighbor has been lost, the receiver should be ready to accept either:

- a message with a sequence number of zero
- a message with a higher sequence number than the last received sequence number.

A router that has forgotten its current sequence number but remembers its key and Key-ID must send its first packet with a sequence number of zero. This leaves a small opening for a replay attack.

Test Setup: Default Setup.

Procedure:
Part A: RUT Transmits Non-decreasing Sequence Numbers
1. Configure the RUT to perform MD5 authentication, with a secret of ABCDEFGHIJKL (0x4142434445464748494A4B4C).
2. Observe the packets transmitted by the RUT.
Part B: RUT Receives Non-decreasing Sequence Numbers
3. Configure the RUT to perform MD5 authentication, with a secret of ABCDEFGHIJKL (0x4142434445464748494A4B4C).
4. TR1 transmits a RIP Response with an authentication header, a sequence number N, and a Route Entry.
5. TR1 transmits a RIP Response with an authentication header, a sequence number N, and the same Route Entry with a better metric.
6. TR1 transmits a RIP Response with an authentication header, a sequence number N+1, and the same Route Entry transmitted in Step 5 with a better metric.
7. Observe the packets transmitted by the RUT.
8. TR1 transmits a RIP Response for the routes learned in this test with a metric of 16.

Part C: RUT Receives Decreasing Sequence Numbers
9. Configure the RUT to perform MD5 authentication, with a secret of ABCDEFGHIJKL (0x4142434445464748494A4B4C).
10. TR1 transmits a RIP Response with an authentication header, a sequence number N+1, and a Route Entry.
11. TR1 transmits a RIP Response with an authentication header, a sequence number N-1, and the same Route Entry transmitted in Step 10 with a better metric.
12. Observe the packets transmitted by the RUT.
13. TR1 transmits a RIP Response for the routes learned in this test with a metric of 16.

Part D: RUT Receives Decreasing Sequence Number with Different Key ID
14. Configure the RUT to perform MD5 authentication, with two different keys (Key IDs 1 and 2) on a single interface. Key ID 1 should have a secret of ABCDEFGHIJKL (0x4142434445464748494A4B4C), and Key ID 2 should have a secret of MNOPQRSTUVWX (0x4D4E4F505152535455565758).
15. TR1 transmits a RIP Response with a properly formatted authentication header for Key ID 1, a sequence number of N+1, and a Route Entry.
16. TR1 transmits a RIP Response with a properly formatted authentication header for Key ID 2, a sequence number of N-1, and a Route Entry.
17. Observe the packets transmitted by the RUT.
18. TR1 transmits a RIP Response for the routes learned in this test with a metric of 16.

Observable Results:
- In Part A, the RUT should transmit periodic RIP Responses with proper MD5 authentication. The sequence numbers in each response should be non-decreasing.
- In Part B, with each RIP Response, the RUT should learn the Route Entry advertised with the new metric.
- In Part C, the RUT should learn the Route Entry in the RIP Response transmitted in Step 10. The RUT should not learn the Route Entry with the new metric transmitted in Step 11.
- In Part D, the RUT should learn the Route Entry in the RIP Response transmitted in Steps 15 and 16.

Possible Problems: None.

Test RIP.4.4: Sequence Number Zero

Purpose: To verify that a router handles a sequence number of zero properly.
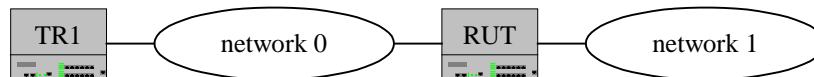
References: [2082] – Section 3.1, 3.2.2

Discussion: MD5 authentication includes the use of an unsigned 32-bit sequence number. The sequence number MUST be non-decreasing for all messages sent with the same Key ID. If the neighbor has been heard from recently enough to have viable routes in the route table and the received sequence number is less than the last one received, the message likewise is discarded unprocessed. When connectivity to the neighbor has been lost, the receiver should be ready to accept either:

- a message with a sequence number of zero
- a message with a higher sequence number than the last received sequence number.

A router that has forgotten its current sequence number but remembers its key and Key-ID must send its first packet with a sequence number of zero. This leaves a small opening for a replay attack.

Test Setup: Default Setup.

Procedure:
Part A: Sequence Number Zero Accepted Due to Link Loss
1. Configure the RUT to perform MD5 authentication, with a secret of ABCDEFGHIJKL (0x4142434445464748494A4B4C).
2. TR1 transmits a RIP Response with an authentication header, a sequence number N, and a Route Entry.
3. Disconnect and reconnect the link connecting the RUT and Network 0.
4. TR1 transmits a RIP Response with an authentication header, a sequence number of zero, and the same Route Entry transmitted in Step 2 with a better metric.
5. Observe the packets transmitted by the RUT.
6. TR1 transmits a RIP Response for the routes learned in this test with a metric of 16.
Part B: Sequence Number Zero Accepted Due to Route Loss
7. Configure the RUT to perform MD5 authentication, with a secret of ABCDEFGHIJKL (0x4142434445464748494A4B4C).
8. TR1 transmits a RIP Response with an authentication header, a sequence number N, and a Route Entry.
9. Wait until the Route Entry in Step 8 has been deleted (300 seconds).
10. TR1 transmits a RIP Response with an authentication header, a sequence number of zero, and the same Route Entry transmitted in Step 8 with a better metric.
11. Observe the packets transmitted by the RUT.
12. TR1 transmits a RIP Response for the routes learned in this test with a metric of 16.

Part C: Sequence Number Zero Not Accepted

13. Configure the RUT to perform MD5 authentication, with a secret of ABCDEFGHIJKL (0x4142434445464748494A4B4C).
14. TR1 transmits a RIP Response with an authentication header, a sequence number N, and a Route Entry.
15. TR1 transmits a RIP Response with an authentication header, a sequence number of zero, and the same Route Entry with a better metric.
16. Observe the packets transmitted by the RUT.
17. TR1 transmits a RIP Response for the routes learned in this test with a metric of 16.

Observable Results:
- In Part A, in Step 4, the RUT should accept the Route Entry and update the metric.
- In Part B, in Step 10, the RUT should accept the Route Entry and update the metric.
- In Part C, in Step 15, the RUT should not accept the Route Entry and update the metric.

Possible Problems: None.

Test RIP.4.5: UDP Checksum

Purpose: To verify that a router accepts MD5 authenticated RIP messages with varying UDP checksums.

References: [2082] – Section 3.2.1
[1812] – Section 6.1

Discussion: During message generation for MD5 authentication, the RIP-2 Packet is created as usual. One exception is that the UDP checksum need not be calculated, but may be set to zero. According to [1812], a message received with an incorrect checksum must be discarded; we interpret this to indicate that the checksum must be set to 0 if it is not calculated.

Test Setup: Default Setup.
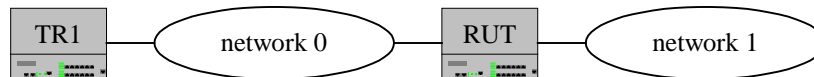
Procedure:
Part A: RUT Rejects Random Incorrect UDP Checksum
1.   Configure the RUT to perform MD5 authentication, with a secret of ABCDEFGHIJKL (0x4142434445464748494A4B4C).
2.   TR1 transmits a RIP Response with a correct authentication header, a Route Entry, and a random, incorrect, UDP checksum.
3.   Observe the packets transmitted by the RUT.
4.   TR1 transmits a RIP Response for the routes learned in this test with a metric of 16.
Part B: RUT Accepts UDP Checksum of Zero
5.   Configure the RUT to perform MD5 authentication, with a secret of ABCDEFGHIJKL (0x4142434445464748494A4B4C).
6.   TR1 transmits a RIP Response with a correct authentication header, a Route Entry, and a UDP checksum of zero.
7.   Observe the packets transmitted by the RUT.
8.   TR1 transmits a RIP Response for the routes learned in this test with a metric of 16.

Observable Results:
*   In Part A, the RUT should not learn the route advertised in the RIP packet.
*   In Part B, the RUT should learn the route advertised in the RIP packet.

Possible Problems: None.

Test RIP.4.6: Key Lifetime Expiry

Purpose: To verify that a router handles key lifetime expiry properly.

References: [2082] – Section 4

Discussion: More than one key may be associated with an interface at the same time. Hence it is possible to have fairly smooth RIP-2 Authentication Key rollovers without losing legitimate RIP-2 messages because the stored key is incorrect and without requiring people to change all the keys at once. To ensure a smooth rollover, each communicating RIP-2 system must be updated with the new key several minutes before the current key will expire and several minutes before the new key lifetime begins. The new key should have a lifetime that starts several minutes before the old key expires. This gives time for each system to learn of the new RIP-2 Authentication Key before that key will be used. It also ensures that the new key will begin being used and the current key will go out of use before the current key's lifetime expires. For the duration of the overlap in key lifetimes, a system may receive messages using either key and authenticate the message. The Key-ID in the received message is used to select the appropriate key for authentication. During key switchover, devices may exist which have not yet been successfully configured with the new key. Therefore, routers should implement (and would be well advised to implement) an algorithm that detects the set of keys being used by its neighbors, and transmits its messages using both the new and old keys until all of the neighbors are using the new key or the lifetime of the old key expires. Under normal circumstances, this elevated transmission rate will exist for a single update interval. In the event that the last key associated with an interface expires, it is unacceptable to revert to an unauthenticated condition, and not advisable to disrupt routing. Therefore, the router should send a "last authentication key expiration" notification to the network manager and treat the key as having an infinite lifetime until the lifetime is extended, the key is deleted by network management, or a new key is configured.

Test Setup: Default Setup.

| TR1 | network 0 | RUT | network 1 | TR2 |

Procedure:
Part A: Lifetime Expires, No New Key
1. Configure the RUT to perform MD5 authentication, with a secret of ABCDEFGHIJKL (0x4142434445464748494A4B4C). Specify a Key ID of 1 and a lifetime of five minutes.
2. TR1 transmits a RIP Response with a correct MD5 authentication header and a Route Entry every sixty seconds until Key ID 1 expires.
3. TR1 transmits a RIP Response with a correct authentication header and the same Route Entry as in Step 2, but with a better metric. Observe the packets transmitted by the RUT.
4. TR1 transmits a RIP Response for the routes learned in this test with a metric of 16.

Part B: Lifetime Expires, New Key

5. Configure the RUT to perform MD5 authentication, with a secret of ABCDEFGHIJKL (0x4142434445464748494A4B4C). Specify a Key ID of 1 and a lifetime of five minutes.
6. Wait one minute. Configure another key with a Key ID of 2, a secret of MNOPQRSTUVWX (0x4D4E4F505152535455565758), and a lifetime of five minutes. Set the new key's lifetime to begin in one minute.
7. Wait one minute. Every sixty seconds until Key ID 1 expires, transmit a RIP Response from TR1 with a correct authentication header, a Route Entry, and a Key ID of 1. Every sixty seconds until Key ID 2 expires, transmit a RIP Response from TR2 with a correct authentication header, a Route Entry, and a Key ID of 2.
8. Observe the packets transmitted by the RUT.
9. TR1 transmits a RIP Response for the routes learned in this test with a metric of 16.

Observable Results:
- In Part A, Step 2, the RUT should learn the route advertised in the RIP packet. The RUT should continue to use the existing key after the lifetime has expired. The timeout for the route learned in Step 2 should be updated by the RIP Response sent in Step 3.
- In Part B, Step 7, the RUT should learn the routes advertised in the RIP packets. The RUT should advertise its routes using both keys, while both keys are still alive. Following the expiry of Key ID 1, the RUT should only transmit its routes using Key ID 2.

Possible Problems: None.