                      Traceroute Using an IP Option

Status of this Memo

Abstract

   Traceroute serves as a valuable network debugging tool. The way in
   which it is currently implemented has the advantage of being
   automatically supported by all of the routers. It's two problems are
   the number of packets it generates and the amount of time it takes to
   run.

   This document specifies a new IP option and ICMP message type which
   duplicates the functionality of the existing traceroute method while
   generating fewer packets and completing in a shorter time.

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1. Traceroute Today

   The existing traceroute operates by sending out a packet with a Time
   To Live (TTL) of 1. The first hop then sends back an ICMP [1] error
   message indicating that the packet could not be forwarded because the
   TTL expired. The packet is then resent with a TTL of 2, and the
   second hop returns the TTL expired. This process continues until the
   destination is reached. The purpose behind this is to record the
   source of each ICMP TTL exceeded message to provide a trace of the
   path the packet took to reach the destination.

   The advantage of this algorithm, is that every router already has the
   ability to send TTL exceeded messages. No special code is required.
   The disadvantages are the number of packets generated (2n, where n is
   the number of hops), the time it takes to duplicate all the nearer
   hops with each successive packet, and the fact that the path may
   change during this process. Also, this algorithm does not trace the
   return path, which may differ from the outbound path.

2. Traceroute Tomorrow

   The proposed traceroute would use a different algorithm to achieve
   the same goal, namely, to trace the path to a host. Because the new
   traceroute uses an ICMP message designed for the purpose, additional
   information, unavailable to the original traceroute user, can be made
   available.

2.1 Basic Algorithm

   A new IP Traceroute option will be defined. The presence of this
   option in an ICMP Echo (or any other) packet, hereinafter referred to
   as the Outbound Packet, will cause a router to send the newly defined
   ICMP Traceroute message to the originator of the Outbound Packet. In
   this way, the path of the Outbound Packet will be logged by the
   originator with only n+1 (instead of 2n) packets. This algorithm
   does not suffer from a changing path and allows the response to the
   Outbound Packet, hereinafter refered to as the Return Packet, to be
   traced (provided the Outbound Packet's destination preserves the IP
   Traceroute option in the Return Packet).

   The disadvantage of this method is that the traceroute function will
   have to be put into the routers. To counter this disadvantage,
   however, is the fact that this mechanism may be easily ported to a
   new IP version.

2.2 IP Traceroute option format

```
  0               8              16              24
 +-+-+-+-+-+-+-+-+--------------+--------------+--------------+
 |F| C |  Number |    Length    |            ID Number        |
 +-+-+-+-+-+-+-+-+--------------+--------------+--------------+
 |      Outbound Hop Count      |      Return Hop Count        |
 +--------------+--------------+--------------+--------------+
 |                   Originator IP Address                    |
 +--------------+--------------+--------------+--------------+
```

F (copy to fragments)

   0 (do not copy to fragments)

C (class)

   2 (Debugging & Measurement)

Number

   18 (F+C+Number = 82)

ID Number

   An arbitrary number used by the originator of the Outbound Packet
   to identify the ICMP Traceroute messages. It is NOT related to
   the ID number in the IP header.

Originator IP Address

   The IP address of the originator of the Outbound Packet. This is
   needed so the routers know where to send the ICMP Traceroute
   message for Return Packets. It is also needed for Outbound
   Packets which have a Source Route option.

Outbound Hop Count (OHC)

   The number of routers through which the Outbound Packet has
   passed. This field is not incremented by the Outbound Packet's
   destination.

Return Hop Count (RHC)

   The number of routers through which the Return Packet has passed.
   This field is not incremented by the Return Packet's destination.

2.3 ICMP Traceroute message format

```
 0               8              16              24
+--------------+--------------+--------------+--------------+
|    Type      |    Code      |         Checksum           |
+--------------+--------------+--------------+--------------+
|         ID Number           |          unused            |
+--------------+--------------+--------------+--------------+
|     Outbound Hop Count      |      Return Hop Count       |
+--------------+--------------+--------------+--------------+
|                    Output Link Speed                     |
+--------------+--------------+--------------+--------------+
|                     Output Link MTU                      |
+--------------+--------------+--------------+--------------+
```

Type

   30

Code

   0 - Outbound Packet successfully forwarded
   1 - No route for Outbound Packet; packet discarded

Checksum

   The 16 bit one's complement of the one's complement sum of all 16
   bit words in the header. For computing the checksum, the checksum
   field should be zero.

ID Number

   The ID Number as copied from the IP Traceroute option of the
   packet which caused this Traceroute message to be sent. This is
   NOT related to the ID number in the IP header.

Outbound Hop Count

   The Outbound Hop Count as copied from the IP Traceroute option of
   the packet which caused this Traceroute message to be sent.

Return Hop Count

   The Return Hop Count as copied from the IP Traceroute option of
   the packet which caused this Traceroute message to be sent.

Output Link Speed

   The speed, in OCTETS per second, of the link over which the
   Outbound/Return Packet will be sent. Since it will not be long
   before network speeds exceed 4.3Gb/s, and since some machines deal
   poorly with fields longer than 32 bits, octets per second was
   chosen over bits per second. If this value cannot be determined,
   the field should be set to zero.

Output Link MTU

   The MTU, in bytes, of the link over which the Outbound/Return
   Packet will be sent. MTU refers to the data portion (includes IP
   header; excludes datalink header/trailer) of the packet. If this
   value cannot be determined, the field should be set to zero.

3. Protocol

   The Outbound Packet which is used to carry the IP Traceroute option
   should use no special Type Of Service (TOS) or Precedence, unless the
   purpose is to trace the path of packets with special TOS or
   Precedence values.

   The TTL of the Outbound Packet should be set to the default value
   specified in "Assigned Numbers" [2].

3.1 Hop Counts

   The hop counts ultimately provide information on the length of the
   outbound and return paths to the destination. They also provide a
   means of determining whether or not any ICMP Traceroute messages have
   been lost. For example, if a Traceroute message with an OHC of 4 is
   followed by a message with an OHC of 6, then the the message with an
   OHC of 5 was lost. This is why simply counting Traceroute messages
   is not sufficient for determining path length.

   The originator of the Outbound Packet should set the OHC to zero and
   the RHC to 0xFFFF. 0xFFFF is a special value which indicates to
   routers that the packet is an Outbound Packet rather than a Return
   Packet (which begins with an RHC of zero).

   It is important to note that the Traceroute hop counts are NOT
   related to the IP TTL. A hop count should only be incremented when
   an ICMP Traceroute message is sent.

3.2 Destination Node Operation

   When a node receives an Outbound Packet with an IP Traceroute option,
   the Return Packet, if such is required (e.g., ICMP Echo
   Request/Reply), should also carry that option. The values in the ID
   Number, OHC, and Originator Address fields should be copied into the
   Return Packet. The value of the RHC field should be set to zero.

   The destination should NOT increment any hop counts or send any ICMP
   Traceroute messages.

3.3 Router Operation

   When a router forwards a packet with an IP Traceroute option, it
   should send an ICMP Traceroute message to the host in the Originator
   IP Address field of the option. If the value of the RHC field is
   0xFFFF then the packet is an Outbound Packet and the OHC should be
   incremented; otherwise, the RHC field should be incremented. The
   Traceroute message should reflect the incremented hop count. The
   Output Link Speed field should be set to the speed, in OCTETS per
   second, of the link over which the Outbound/Return Packet will be
   sent (e.g., 1,250,000 for an Ethernet) or zero if the output link
   speed cannot be determined. The Output Link MTU field should be set
   to the MTU of the link over which the Outbound/Return Packet will be
   sent or zero if the MTU cannot be determined.

   The Outbound/Return Packet should be forwarded as though the
   Traceroute option did not exist; that is, it should take the same
   path to the destination as an optionless packet.

   The ICMP Traceroute message should have the same TOS and Precedence
   values as the Outbound/Return Packet. The TTL should be set to the
   default defined in "Assigned Numbers".

   The ICMP Traceroute message should not carry the IP Traceroute
   option.

   If the Outbound Packet cannot be forwarded, the ICMP Traceroute
   message should have a Code value of 1. If the Return Packet cannot
   be forwarded because there is no route, then there is no need to send
   a Traceroute message since it could not be forwarded either.

4. References

   [1] Postel, J., "Internet Control Message Protocol", STD 5, RFC 792,
       USC/Information Sciences Institute, September 1981.

   [2] Reynolds, J., and J. Postel, "Assigned Numbers", STD 2, RFC 1340,
       USC/Information Sciences Institute, July 1992.

5. Security Considerations

   Security issues are not discussed in this memo.

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