TWAMP Reflect Octets and Symmetrical Size Features
draft-ietf-ippm-twamp-reflect-octets-05

Abstract

The IETF has completed its work on the core specification of TWAMP -
the Two-Way Active Measurement Protocol. This memo describes two
closely-related features for TWAMP: an optional capability where the
responder host returns some of the command octets or padding octets to
the controller, and an optional sender packet format that ensures equal
test packet sizes are used in both directions.

Requirements Language

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT",
"SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this
document are to be interpreted as described in RFC 2119 (Bradner, S.,
"Key words for use in RFCs to Indicate Requirement Levels,"
March 1997.) [RFC2119].

Status of this Memo

Copyright Notice

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1. Introduction

The IETF has completed its work on the core specification of TWAMP - the Two-Way Active Measurement Protocol [RFC5357] (Hedayat, K., Krzanowski, R., Morton, A., Yum, K., and J. Babiarz, "A Two-Way Active Measurement Protocol (TWAMP)," October 2008.). TWAMP is an extension of the One-way Active Measurement Protocol, OWAMP [RFC4656] (Shalunov, S., Teitelbaum, B., Karp, A., Boote, J., and M. Zekauskas, "A One-way Active Measurement Protocol (OWAMP)," September 2006.). The TWAMP specification gathered wide review as it approached completion, and the by-products were several recommendations for new features in TWAMP. There are a growing number TWAMP implementations at present, and wide-spread usage is expected. There are even devices that are designed to test implementations for protocol compliance.

This memo describes two closely-related features for TWAMP.

One is the OPTIONAL capability for the responder host to return a limited number of unassigned (padding) octets to the Control-Client or Session-Sender entities. With this capability, the Control-Client or Session-Sender can embed octets of information it deems useful and have the assurance that the corresponding reply/test packet will contain that information when it is reflected and returned (by the Server or Session-Reflector.

The memo also adds an OPTIONAL capability to assure that reflected test packets are the same size in both directions of transmission. This is accomplished by specifying a new TWAMP-Test Session-Sender packet format.

This memo is an update to the TWAMP core protocol specified in [RFC5357] (Hedayat, K., Krzanowski, R., Morton, A., Yum, K., and J. Babiarz, "A Two-Way Active Measurement Protocol (TWAMP)," October 2008.). Measurement systems are not required to implement the features described in this memo to claim compliance with [RFC5357] (Hedayat, K., Krzanowski, R., Morton, A., Yum, K., and J. Babiarz, "A Two-Way Active Measurement Protocol (TWAMP)," October 2008.).

Throughout this memo, the bits marked MBZ (Must Be Zero) MUST be set to zero by senders and MUST be ignored by receivers. Also, the HMAC (Hashed Message Authentication Code) MUST be calculated as defined in Section 3.2 of [RFC4656] (Shalunov, S., Teitelbaum, B., Karp, A.,

Boote, J., and M. Zekauskas, "A One-way Active Measurement Protocol (OWAMP)," September 2006.).

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2. Purpose and Scope

The purpose of this memo is to define two OPTIONAL closely-related features for TWAMP [RFC5357] (Hedayat, K., Krzanowski, R., Morton, A., Yum, K., and J. Babiarz, "A Two-Way Active Measurement Protocol (TWAMP)," October 2008.). The features enhance the TWAMP responder's capabilities to perform simple operations on control and test packets: the reflection of octets or padding and symmetrical sizes of fields in the TWAMP-Test packets. Motivations include permitting the controller host to tag packets with an index for simplified identification, and/or assert that the same size test packets will be used in each direction. The scope of the memo is limited to specifications of the following features:

    *Reflect Octets: the capability of the Server/Session-Reflector to
     reflect specific octets back to the Client/Session-Sender.

    *Symmetrical Size: the capability to ensure that TWAMP-Test
     protocol uses the same packet size in both directions through
     support of a new TWAMP-Test Session-Sender test packet format in
     both the Session-Sender and the Session-Reflector. Only the
     Session-Sender test packet format is new.

This memo extends the modes of operation through assignment of two new values in the Modes Field (see section 3.1 of[RFC4656] (Shalunov, S., Teitelbaum, B., Karp, A., Boote, J., and M. Zekauskas, "A One-way Active Measurement Protocol (OWAMP)," September 2006.) for the format of the Server Greeting message), while retaining backward compatibility with the core TWAMP [RFC5357] (Hedayat, K., Krzanowski, R., Morton, A., Yum, K., and J. Babiarz, "A Two-Way Active Measurement Protocol (TWAMP)," October 2008.) implementations. The two new values correspond to the two features defined in this memo.
When the Server and Control-Client have agreed to use the Reflect Octets mode during control connection setup, then the Control-Client, the Server, the Session-Sender, and the Session-Reflector MUST all conform to the requirements of that mode, as identified below.
When the Server and Control-Client have agreed to use the Symmetrical Size mode during control connection setup, then the Control-Client, the Server, the Session-Sender, and the Session-Reflector MUST all conform to the requirements of that mode, as identified below.

---

3. TWAMP Control Extensions

TWAMP-Control protocol [RFC5357] (Hedayat, K., Krzanowski, R., Morton, A., Yum, K., and J. Babiarz, "A Two-Way Active Measurement Protocol (TWAMP)," October 2008.) uses the Modes Field to identify and select specific communication capabilities, and this field is a recognized extension mechanism. The following sections describe two such extensions.

3.1. Connection Setup with New Features

TWAMP connection establishment follows the procedure defined in section 3.1 of [RFC4656] (Shalunov, S., Teitelbaum, B., Karp, A., Boote, J., and M. Zekauskas, "A One-way Active Measurement Protocol (OWAMP)," September 2006.) and section 3.1 of [RFC5357] (Hedayat, K., Krzanowski, R., Morton, A., Yum, K., and J. Babiarz, "A Two-Way Active Measurement Protocol (TWAMP)," October 2008.). The new features require two new bit positions (and values) to identify the ability of the Server/Session-Reflector to reflect specific octets back to the Control-Client/ Session-Sender, and to support the new Session-Sender packet format in TWAMP-Test Protocol. With this added feature, the complete set of TWAMP Modes Field bit positions and values would be as follows:

```
Value   Description            Reference/Explanation
0       Reserved
1       Unauthenticated        RFC4656, Section 3.1
2       Authenticated          RFC4656, Section 3.1
4       Encrypted              RFC4656, Section 3.1
8       Unauth. TEST protocol, RFC5681, Section 3.1
        Encrypted CONTROL
16      Individual Session     RFC????, Section 3.1
        Control
---------------------------------------------------------
xxx     Reflect Octets         new bit position (X)
        Capability
yyy     Symmetrical Size       new bit position (Y)
        Sender Test Packet Format
```

In the original OWAMP Modes Field, setting bit positions 0, 1 or 2 indicated the security mode of the Control protocol, and the Test protocol inherited the same mode (see section 4 of [RFC4656] (Shalunov, S., Teitelbaum, B., Karp, A., Boote, J., and M. Zekauskas, "A One-way Active Measurement Protocol (OWAMP)," September 2006.)). In [RFC5618] (Morton, A. and K. Hedayat, "Mixed Security Mode for the Two-Way Active Measurement Protocol (TWAMP)," August 2009.), bit position 3 allows

unauthenticated TWAMP Test protocol to be used with encryption on the TWAMP-Control protocol in a mixed mode of operation.
The Server sets one or both of the new bit positions (X and Y) in the Modes Field of the Server Greeting message to indicate its capabilities and willingness to operate in either of these modes (or both) if desired.
>>>IANA: change xxx, yyy, X, Y, and RFC???? to the assigned values <<<
If the Control-Client intends to operate all test sessions invoked with this control connection using one or both of the new modes, it MUST set the Mode Field bit corresponding to each function in the Setup Response message. With this and other extensions, the Control-Client MAY set multiple Mode Field bits in the Setup Response message.

3.2. Reflect Octets: Request-TW-Session Packet Format

The bits designated for the Reflect Octets feature in the Request-TW-Session command are as shown in the packet format below.

```
    0                   1                   2                   3
    0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |       5       |  MBZ  | IPVN  |  Conf-Sender  | Conf-Receiver |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                    Number of Schedule Slots                   |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   .                                                               .
   .             ... Many fields (66 octets) not shown ...         .
   .                                                               .
   .                                                               .
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                    Padding Length  (4 octets)                 |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                     Start Time, (8 octets)                    |
   |                                                               |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                      Timeout, (8 octets)                      |
   |                                                               |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                      Type-P Descriptor                        |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |     Octets to be reflected    |  Length of padding to reflect |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                       MBZ (4 octets)                          |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                                                               |
   |                      HMAC (16 octets)                         |
   |                                                               |
   |                                                               |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

The "Padding Length" Field *continues* to specify the number of padding
octets that the Session-Sender will append to ALL TWAMP-Test packets
associated with this test session. See below for considerations on the
minimum length of the padding octets, following the definitions of the
two new fields that follow the Type-P Descriptor.
Note that the number of padding octets appended to the Session-
Reflector's test packet depends on support for the RECOMMENDED
truncation process in TWAMP section 4.2.1 [RFC5357] (Hedayat, K.,
Krzanowski, R., Morton, A., Yum, K., and J. Babiarz, "A Two-Way Active
Measurement Protocol (TWAMP)," October 2008.).
The "Octets to be reflected" Field SHALL be 2 octets long, as shown and
contains the octets that the Server MUST reflect in the Accept Session
message as specified below.
The "Length of padding to reflect" Field SHALL be 2 octets long, and
contain an unsigned binary value in units of octets. This field
communicates the length of the padding in the TWAMP-Test Packet that

the Session-Sender expects to be reflected, and the length of octets that the Session-Reflector SHALL return in include in its TWAMP-Test packet format (see section 4.2). By including this length field in the Request-TW-Session message, a Server is able to determine if it can comply with a specific request to reflect padding in the TWAMP-Test packets, and to arrange for the Session-Reflector processing in advance.

The "Padding Length" SHOULD be >= 27 octets when specifying a test session using the Unauthenticated TWAMP-Test mode, to allow for the RECOMMENDED truncation process in TWAMP section 4.2.1 [RFC5357] (Hedayat, K., Krzanowski, R., Morton, A., Yum, K., and J. Babiarz, "A Two-Way Active Measurement Protocol (TWAMP)," October 2008.).

The "Padding Length" SHOULD be >= 56 octets when specifying a test session using the Authenticated or Encrypted TWAMP-Test modes, to allow for the RECOMMENDED truncation process in TWAMP section 4.2.1 [RFC5357] (Hedayat, K., Krzanowski, R., Morton, A., Yum, K., and J. Babiarz, "A Two-Way Active Measurement Protocol (TWAMP)," October 2008.).

The "Padding Length" SHALL be > the "Length of padding to reflect" when specifying a test session using the OPTIONAL Reflect Octets mode.

In Unauthenticated TWAMP-Test mode, the "Padding Length" SHALL be >= 27 + "Length of padding to reflect" octets when specifying a test session using BOTH the OPTIONAL Reflect Octets mode and the RECOMMENDED truncation process in TWAMP section 4.2.1 [RFC5357] (Hedayat, K., Krzanowski, R., Morton, A., Yum, K., and J. Babiarz, "A Two-Way Active Measurement Protocol (TWAMP)," October 2008.).

In Authenticated or Encrypted TWAMP-Test modes, the "Padding Length" SHALL be >= 56 + "Length of padding to reflect" octets when specifying a test session using BOTH the OPTIONAL Reflect Octets mode and the RECOMMENDED truncation process in TWAMP section 4.2.1 [RFC5357] (Hedayat, K., Krzanowski, R., Morton, A., Yum, K., and J. Babiarz, "A Two-Way Active Measurement Protocol (TWAMP)," October 2008.).

3.3. Reflect Octets: Accept Session Packet Format

The bits designated for the Reflect Padding feature in the Accept Session command are as shown in the packet format below.

```
   0                   1                   2                   3
   0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
  +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
  |    Accept     |      MBZ      |                Port           |
  +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-|
  |                                                               |
  |                        SID (16 octets)                        |
  |                                                               |
  |                                                               |
  +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
  |        Reflected octets       |         Server octets         |
  +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
  |                        MBZ (8 octets)                         |
  |                                                               |
  +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
  |                                                               |
  |                        HMAC (16 octets)                       |
  |                                                               |
  |                                                               |
  +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

The "Reflected octets" field SHALL contain the octets from the Request-
TW-Session "Octets to be reflected" Field, and be 2 octets long, as
shown.

The "Server octets" field SHALL contain information that the Server
intends to be returned in the TWAMP-Test packet padding to-be-reflected
Field, OR SHALL be zero, and be 2 octets long, as shown. Although the
Server determines the SID, this field is very long (16 octets) and does
not normally appear in TWAMP-Test packets.

When supporting the RECOMMENDED truncation process in TWAMP section
4.2.1 [RFC5357] (Hedayat, K., Krzanowski, R., Morton, A., Yum, K., and
J. Babiarz, "A Two-Way Active Measurement Protocol (TWAMP),"
October 2008.), IF calculations on the Padding lengths reveal that
there are insufficient octets supplied to produce equal-length Session-
Sender and Session-Reflector test packets, then the Accept Field MUST
be set to 3 = some aspect of the request is not supported.

3.4. Additional considerations

The value of the Modes Field sent by the Server in the Server Greeting
message is the bit-wise OR of the mode values that it is willing to
support during this session.

With the publication of this memo as an RFC, the last 7 bit positions
of the Modes 32-bit Field are used. A Control-Client conforming to this
extension of [RFC5357] (Hedayat, K., Krzanowski, R., Morton, A., Yum,

K., and J. Babiarz, "A Two-Way Active Measurement Protocol (TWAMP),"
October 2008.) MAY ignore the values in the higher bits of the Modes
Field, or it MAY support other features that are communicated in those
bit positions. The other bits are available for future protocol
extensions.

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4. Extended TWAMP Test

The TWAMP test protocol is similar to the OWAMP [RFC4656] (Shalunov,
S., Teitelbaum, B., Karp, A., Boote, J., and M. Zekauskas, "A One-way
Active Measurement Protocol (OWAMP)," September 2006.) test protocol
with the exception that the Session-Reflector transmits test packets to
the Session-Sender in response to each test packet it receives. TWAMP
section 4[RFC5357] (Hedayat, K., Krzanowski, R., Morton, A., Yum, K.,
and J. Babiarz, "A Two-Way Active Measurement Protocol (TWAMP),"
October 2008.) defines two additional test packet formats for packets
transmitted by the Session-Reflector. The appropriate format depends on
the security mode chosen. The new modes specified here utilize some of
the padding octets within each test packet format, or require
truncation of those octets depending on the security mode in use.

4.1. Sender Behavior

This section describes extensions to the behavior of the TWAMP Session-
Sender.

4.1.1. Packet Timings

The Send Schedule is not utilized in TWAMP, and this is unchanged in
this memo.

4.1.2. Reflect Octets: Packet Formats and Contents

The Session-Sender packet format and content follow the same procedure
and guidelines as defined in section 4.1.2 of [RFC4656] (Shalunov, S.,
Teitelbaum, B., Karp, A., Boote, J., and M. Zekauskas, "A One-way
Active Measurement Protocol (OWAMP)," September 2006.) (as indicated in
section 4.1.2 of TWAMP [RFC5357] (Hedayat, K., Krzanowski, R., Morton,

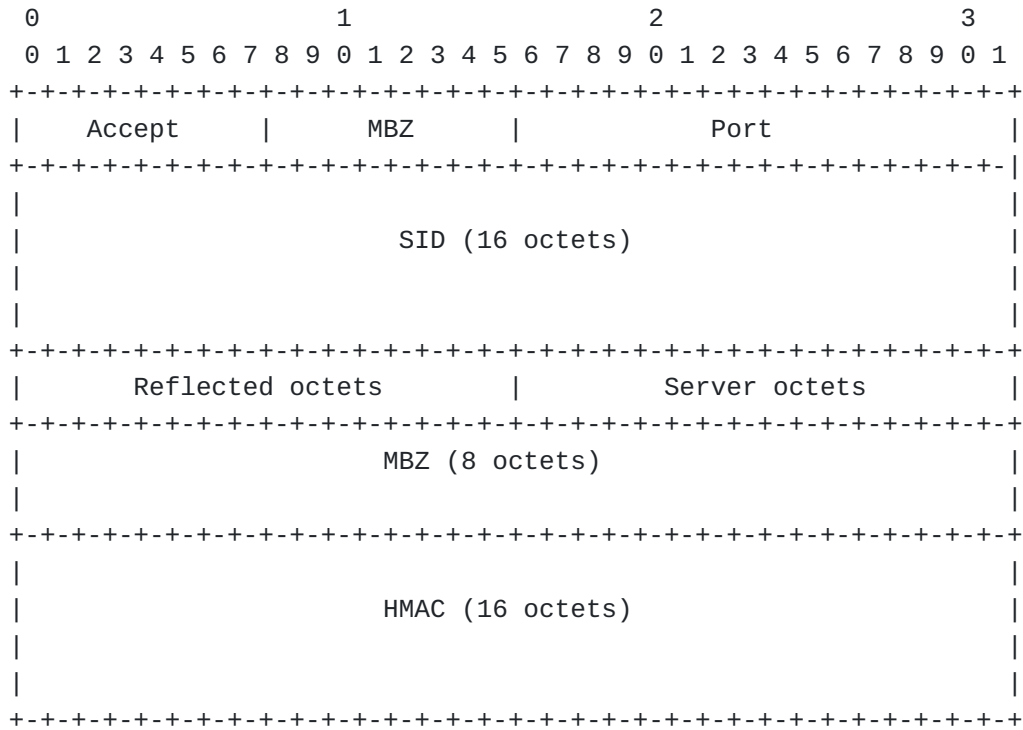A., Yum, K., and J. Babiarz, "A Two-Way Active Measurement Protocol (TWAMP)," October 2008.)).
The Reflect octets mode re-designates the original TWAMP-Test (and OWAMP-Test) Packet Padding Field (see section 4.1.2 of [RFC4656] (Shalunov, S., Teitelbaum, B., Karp, A., Boote, J., and M. Zekauskas, "A One-way Active Measurement Protocol (OWAMP)," September 2006.)), as shown below for unauthenticated mode:

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                       Sequence Number                         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                         Timestamp                             |
|                                                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|          Error Estimate        |                              |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+                              +
|                                                               |
|                  Packet Padding (to be reflected)             |
.                (length in octets specified in command)        .
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
.                                                               .
.                    Additional Packet Padding                  .
.                                                               .
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

The "Packet Padding (to be reflected)" Field SHALL correspond to the length of octets specified in the Request-TW-Session "Length of padding to reflect" Field to this test session. These are the octets that the Session-Sender expects will be returned by the Session-Reflector.
The length of the "Additional Packet Padding" Field is the difference between two fields in the Request-TW-Session command, as follows:
"Additional Packet Padding", in octets =
"Padding Length" - "Length of padding to reflect"
One possible use of the first 4 octets of the "Packet Padding (to be reflected)" Field is shown below:

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
                            +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                            |          Server octets        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|          Client octets         |                             |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+                             +
|                  Packet Padding (to be reflected)            |
.                (length in octets specified elsewhere)        .
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

In this example, the "Client octets" and the "Server octets" fields contain the same information that the Client and Server exchanged in the Request-TW-Session and Accept-Session messages corresponding to this specific test session. These octets would be reflected the same as the rest of the "Packet Padding (to be reflected)" Field.

4.1.3. Reflect Octets: Interaction with Padding Truncation

When the Reflect Octets mode is selected, and the RECOMMENDED truncation process in TWAMP section 4.2.1 [RFC5357] (Hedayat, K., Krzanowski, R., Morton, A., Yum, K., and J. Babiarz, "A Two-Way Active Measurement Protocol (TWAMP)," October 2008.) is supported, the Session-Sender MUST anticipate a minimum padding required to achieve equal size test packets in both directions. The amount of padding needed to achieve symmetrical packet size depends on BOTH the security mode (Unauthenticated/Authenticated/Encrypted) and whether the Reflect Octets mode is selected simultaneously.
When using the RECOMMENDED truncation process in TWAMP section 4.2.1 [RFC5357] (Hedayat, K., Krzanowski, R., Morton, A., Yum, K., and J. Babiarz, "A Two-Way Active Measurement Protocol (TWAMP)," October 2008.) alone, the Session-Sender MUST append sufficient Packet Padding octets to allow the same IP packet payload lengths to be used in each direction of transmission (this is usually desirable). To compensate for the Session-Reflector's larger test packet format, the Session-Sender MUST append at least 27 octets of padding in Unauthenticated mode, and at least 56 octets in Authenticated and Encrypted modes. The sizes of TWAMP Test protocol packets and the resulting truncated padding to achieve equal packet sizes in both directions are shown in the table below:

Octets in:	Unauthenticated Mode	Auth/Encrypted Mode
Reflector Header	41	104
Sender Header	14	48
Truncated Padding	27	56

TWAMP-Test Padding Trucation

When using the Reflect Octets mode simultaneously with the RECOMMENDED truncation process in TWAMP section 4.2.1 [RFC5357] (Hedayat, K., Krzanowski, R., Morton, A., Yum, K., and J. Babiarz, "A Two-Way Active Measurement Protocol (TWAMP)," October 2008.), the Session-Sender MUST append at least 27 octets of padding plus the "Length of the padding to reflect" octets when operating in Unauthenticated mode. The Session-

Sender MUST append at least 56 octets of padding plus the "Length of
the padding to reflect" octets when operating in Authenticated and
Encrypted modes.

4.1.4. Symmetrical Size: Session-Sender Packet Format

When the Symmetrical Size mode is selected, the Session-Sender SHALL
use the following TWAMP-Test Packet Format in Unauthenticated mode:
Unauthenticated Mode

```
    0                   1                   2                   3
    0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                        Sequence Number                        |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                          Timestamp                            |
   |                                                               |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |         Error Estimate        |                               |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+                               +
   |                                                               |
   |                                                               |
   |                        MBZ (27 octets)                        |
   |                                                               |
   |                                                               |
   |                                                               |
   +              +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |              |                                                |
   +-+-+-+-+-+-+-+-+                                               +
   .                                                               .
   .                        Packet Padding                         .
   .                                                               .
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```
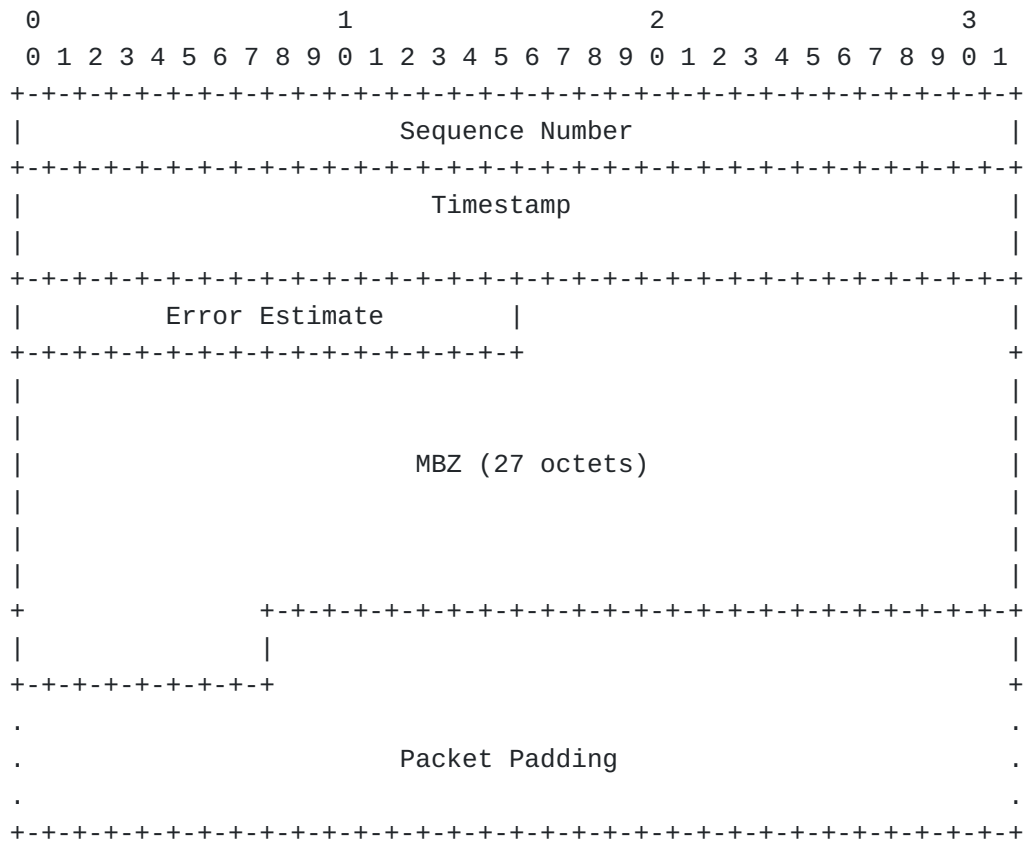
This feature REQUIRES only a new Session-Sender test packet format, the
Session-Reflector test packet format is unchanged.

4.1.5. Symmetrical Size AND Reflect Octets: Session-Sender Packet Format

When BOTH the Symmetrical Size mode and the Reflect Octets mode are
selected, the Session-Sender SHALL use the following TWAMP-Test Packet
Format in Unauthenticated mode:
Unauthenticated Mode

```
    0                   1                   2                   3
    0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                       Sequence Number                        |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                         Timestamp                            |
   |                                                              |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |          Error Estimate        |                             |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+                             +
   |                                                              |
   |                                                              |
   |                       MBZ (27 octets)                        |
   |                                                              |
   |                                                              |
   |                                                              |
   +               +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |               |                                              |
   +-+-+-+-+-+-+-+-+                                              +
   |                  Packet Padding (to be reflected)           |
   .                  (length in octets specified in command)    .
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   .                                                              .
   .                  Additional Packet Padding                  .
   .                                                              .
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```
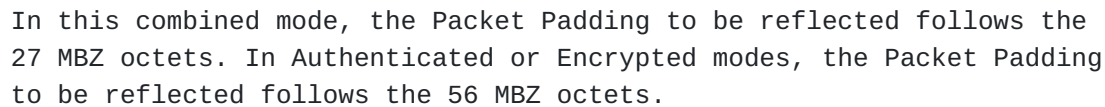
In this combined mode, the Packet Padding to be reflected follows the
27 MBZ octets. In Authenticated or Encrypted modes, the Packet Padding
to be reflected follows the 56 MBZ octets.

4.2. Reflector Behavior   TOC

The TWAMP Reflector follows the procedures and guidelines in section
4.2 of [RFC5357] (Hedayat, K., Krzanowski, R., Morton, A., Yum, K., and
J. Babiarz, "A Two-Way Active Measurement Protocol (TWAMP),"
October 2008.), with the following additional functions:

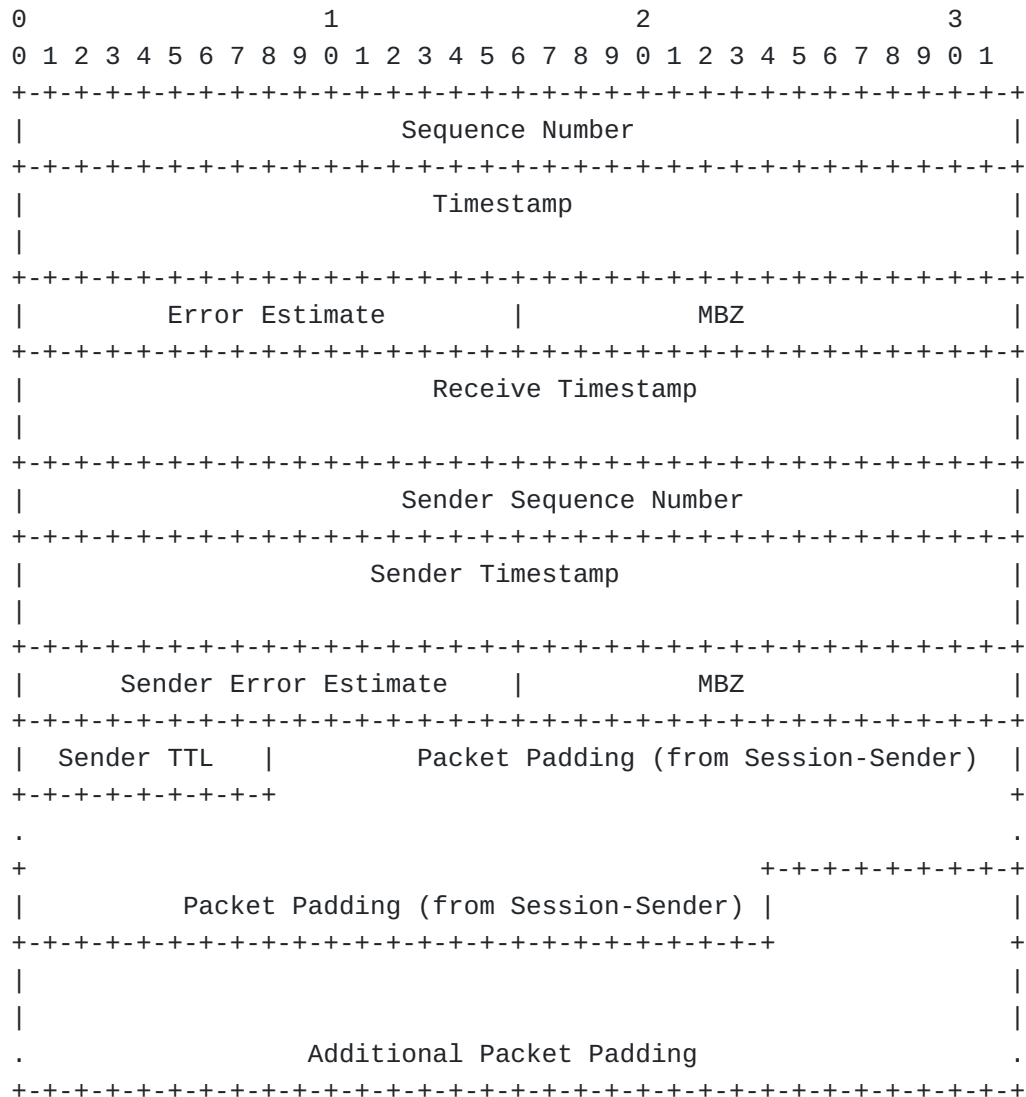   *Reflect Octets mode: Designated octets in the "Packet Padding (to
    be reflected)" field of the Session-Sender's test packet MUST be
    included in the Session-Reflector's test packet.

   *Symmetrical Size mode: The Session-Reflector MUST operate using
    the Session_Reflector Packet Format defined in section 4.1.4,
    where the Padding Octets are separated from the information
    fields.

4.2.1. Reflect Octets: Session-Reflector Packet Format and Contents

The Reflect Padding feature re-designates the packet padding field, as shown below. When the Reflect Octets mode is selected, the Session-Sender SHALL use the following TWAMP-Test Packet Format in Unauthenticated mode:

```
    0                   1                   2                   3
    0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                        Sequence Number                        |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                          Timestamp                            |
   |                                                               |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |         Error Estimate        |              MBZ              |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                       Receive Timestamp                       |
   |                                                               |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                     Sender Sequence Number                    |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                       Sender Timestamp                        |
   |                                                               |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |      Sender Error Estimate    |              MBZ              |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |   Sender TTL   |     Packet Padding (from Session-Sender)   |
   +-+-+-+-+-+-+-+-+                                               +
   .                                                               .
   +                               +-+-+-+-+-+-+-+-+
   |          Packet Padding (from Session-Sender) |               |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+                +
   |                                                               |
   |                                                               |
   .                     Additional Packet Padding                .
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

The "Packet Padding (from Session-Sender)" field MUST be the same octets as the "Packet Padding (to be reflected)" field in the Session-Sender's test packet, and therefore MUST conform to the length specified in the Request-TW-Session message.
When simultaneously using the RECOMMENDED truncation process in TWAMP section 4.2.1 [RFC5357] (Hedayat, K., Krzanowski, R., Morton, A., Yum,

K., and J. Babiarz, "A Two-Way Active Measurement Protocol (TWAMP),"
October 2008.) AND Reflect octets mode, the Session-Reflector MUST
reflect the designated octets from the Session-Sender's test packet in
the "Packet Padding (from Session-Sender)" Field, and MAY re-use
additional Packet Padding from the Session-Sender. The Session-
Reflector MUST truncate the padding such that the highest number octets
are discarded, and the test packet length equals the Session-Sender's
packet length. When using the RECOMMENDED truncation process, the
Session-Reflector MUST truncate exactly 27 octets of padding in
Unauthenticated mode, and exactly 56 octets in Authenticated and
Encrypted modes.
The Session-Reflector MAY re-use the Sender's Packet Padding (since the
requirements for padding generation are the same for each).

4.2.2. Symmetrical Size: Session-Reflector Packet Format

When Symmetrical Size mode is selected, the Session-Sender packet
formats for unauthenticated and authenticated/encrypted modes are
identical to the core TWAMP specification, section 4.2.1 of [RFC5357]
(Hedayat, K., Krzanowski, R., Morton, A., Yum, K., and J. Babiarz, "A
Two-Way Active Measurement Protocol (TWAMP)," October 2008.). Thus, the
Session-Reflector test packet format is unchanged.
The Session-Reflector MUST construct its test packet using the
information in the Session-Sender's test packet. The length of the
Session-Reflector's test packet SHALL equal the length of the Session-
Sender's test packet.

4.2.3. Symmetrical Size AND Reflect Octets: Session-Sender
Packet Format

When BOTH the Symmetrical Size mode and the Reflect Octets mode are
selected, the Session-Reflector MUST operate using the
Session_Reflector Packet Format defined in section 4.1.5, where the
Padding Octets are separated from the information fields, and the
Padding to be Reflected field precedes the Additional Padding.
The Session-Reflector SHALL use the same TWAMP-Test Packet Format as
specified in section 4.2.1 above.

---

5. Security Considerations

These extended modes of operation do not appear to permit any new attacks on hosts communicating with core TWAMP [RFC5357] (Hedayat, K., Krzanowski, R., Morton, A., Yum, K., and J. Babiarz, "A Two-Way Active Measurement Protocol (TWAMP)," October 2008.).
The security considerations that apply to any active measurement of live networks are relevant here as well. See [RFC4656] (Shalunov, S., Teitelbaum, B., Karp, A., Boote, J., and M. Zekauskas, "A One-way Active Measurement Protocol (OWAMP)," September 2006.) and [RFC5357] (Hedayat, K., Krzanowski, R., Morton, A., Yum, K., and J. Babiarz, "A Two-Way Active Measurement Protocol (TWAMP)," October 2008.).

6. IANA Considerations TOC

This memo adds two modes to the IANA registry for the TWAMP Modes Field, and describes behavior when the new modes are used. This field is a recognized extension mechanism for TWAMP.

6.1. Registry Specification TOC

IANA has created a TWAMP-Modes registry (as requested in [RFC5618] (Morton, A. and K. Hedayat, "Mixed Security Mode for the Two-Way Active Measurement Protocol (TWAMP)," August 2009.)). TWAMP-Modes are specified in TWAMP Server Greeting messages and Set-up Response messages, as described in section 3.1 of [RFC5357] (Hedayat, K., Krzanowski, R., Morton, A., Yum, K., and J. Babiarz, "A Two-Way Active Measurement Protocol (TWAMP)," October 2008.), consistent with section 3.1 of [RFC4656] (Shalunov, S., Teitelbaum, B., Karp, A., Boote, J., and M. Zekauskas, "A One-way Active Measurement Protocol (OWAMP)," September 2006.), and extended by this memo. Modes are indicated by setting bits in the 32-bit Modes field that correspond to values in the Modes registry. For the TWAMP-Modes registry, we expect that new features will be assigned increasing registry values that correspond to single bit positions, unless there is a good reason to do otherwise (more complex encoding than single bit positions may be used in the future, to access the 2^32 value space).

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6.2. Registry Management

This registry must be updated only by "IETF Consensus" as specified in [RFC5226] (Narten, T. and H. Alvestrand, "Guidelines for Writing an IANA Considerations Section in RFCs," May 2008.)(an RFC documenting registry use that is approved by the IESG).

6.3. Experimental Numbers

No experimental values are currently assigned for the Modes Registry.

6.4. Registry Contents

TWAMP Modes Registry is recommended to be augmented as follows:

```
Value  Description            Semantics Definition
0      Reserved

1      Unauthenticated        RFC4656, Section 3.1

2      Authenticated          RFC4656, Section 3.1

4      Encrypted              RFC4656, Section 3.1

8      Unauth. TEST protocol, RFC5618, Section 3.1 (3)
       Auth. CONTROL
16     Individual Session     RFC????, Section 3.1
       Control                bit position (4)
       -------------------------------------------------------
xxx    Reflect Octets         this memo, section 3.1
       Capability             new bit position (X)
yyy    Symmetrical Size       this memo, section 3.1
       Sender Test Packet Format new bit position (Y)
```

The suggested values are
X=5, xxx=32
Y=6, yyy=64

---

7. Acknowledgements

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8. References [TOC]

8.1. Normative References [TOC]

[RFC2119]	Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels," BCP 14, RFC 2119, March 1997 (TXT, HTML, XML).
[RFC4656]	Shalunov, S., Teitelbaum, B., Karp, A., Boote, J., and M. Zekauskas, "A One-way Active Measurement Protocol (OWAMP)," RFC 4656, September 2006 (TXT).
[RFC5226]	Narten, T. and H. Alvestrand, "Guidelines for Writing an IANA Considerations Section in RFCs," BCP 26, RFC 5226, May 2008 (TXT).
[RFC5357]	Hedayat, K., Krzanowski, R., Morton, A., Yum, K., and J. Babiarz, "A Two-Way Active Measurement Protocol (TWAMP)," RFC 5357, October 2008 (TXT).
[RFC5618]	Morton, A. and K. Hedayat, "Mixed Security Mode for the Two-Way Active Measurement Protocol (TWAMP)," RFC 5618, August 2009 (TXT).

8.2. Informative References [TOC]

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