Representing Multi-Value Time in Mobile Ad Hoc Networks (MANETs)

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Abstract

   This document describes a general and flexible TLV (type-length-value
   structure) for representing time-values, such as an interval or a
   duration, using the generalized Mobile Ad hoc NETwork (MANET) packet/
   message format. It defines two Message TLVs and two Address Block
   TLVs for representing validity and interval times for MANET routing
   protocols.

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1. Introduction

   The generalized packet/message format [RFC5444] specifies a signaling
   format that MANET routing protocols can employ for exchanging
   protocol information. This format presents the ability to express
   and associate attributes to packets, messages, or addresses, by way
   of a general TLV (type-length-value) mechanism.

   This document specifies a general Time TLV structure, which can be
   used by any MANET routing protocol that needs to express either
   single time-values or a set of time-values with each time-value
   associated with a range of hop counts, as provided by the Message
   Header of [RFC5444]. This allows a receiving node to determine a
   single time-value if either it knows its hop count from the
   originator node or the Time TLV specifies a single time-value.

   A time-value is, in this context, not an "absolute point in time",
   but rather an interval or a duration. An instance of a Time TLV can,
   therefore, express an interval or a duration such as "10 seconds".

   This document also specifies two Message TLV Types, which use the TLV
   structure proposed. These TLV Types are INTERVAL_TIME and
   VALIDITY_TIME, specifying, respectively, the maximum time before
   another message of the same type as this message from the same
   originator should be received, and the duration for which the
   information in this message is valid after receipt. Note that, if
   both are present, then the latter will usually be greater than the
   former in order to allow for possible message loss.

   This document also specifies two Address Block TLV Types, which use
   the TLV structure proposed. These TLV Types are INTERVAL_TIME and
   VALIDITY_TIME, defined equivalently to the two Message TLVs with the
   same names.

1.1. Motivation and Rationale

   The Time TLV structure, specified in this document, is intended to be
   used as a component in a MANET routing protocol, e.g., to indicate
   the expected spacing between successive transmissions of a given
   Message Type, by including a Time TLV in transmitted messages.

   Some MANET routing protocols may employ very short spacing for some
   messages and very long spacing for others, or may change the message
   transmission rate according to observed behavior. For example, if a
   network is observed at some point in time to exhibit a highly dynamic
   topology, a very short (sub-second) message spacing could be
   appropriate, whereas if the network later is observed to stabilize,
   multi-hour message spacing may become appropriate. Different MANET

routing protocols and different deployments of MANET routing
protocols may have different granularity requirements and bounds on
shortest and longest spacing between successive message
transmissions.

In addition, MANET routing protocol deployments typically use
bandwidth-limited wireless network interfaces, and therefore prefer
to trade off computational complexity for a saving in the number of
bits transmitted. This is practical in this case, because the
intended usages of Time TLVs, including the specified examples of
message interval time and information validity time, do not require
high-precision values of time.

The Time TLV structure, specified in this document, caters to these
characteristics by:

o encoding time-values, such as an interval or a duration, in an
   8-bit field; while

o allowing these time-values to range from "very small" (e.g.,
   1/1024 second) to "very long" (e.g., 45 days); and

o allowing a MANET routing protocol, or a deployment, to
   parameterize this (e.g., to attain finer granularity at the
   expense of a lower upper bound) through a single parameter, C.

The parameter C must be the same for all MANET routers in the same
deployment.

The TLV mechanism as specified in [RFC5444] allows associating a
"value" to either a packet, a message, or to addresses. The data
structure for doing so -- the TLV -- is identical in each of the
three cases; however, the TLV's position in a received packet allows
determining if that TLV is a "Packet TLV" (it appears in the Packet
Header, before any messages), a "Message TLV" (it appears in the TLV
Block immediately following a Message Header), or an "Address Block
TLV" (it appears in the TLV Block immediately following an Address
Block).

While TLVs may be structurally identical, that which they express may
be different. This is determined from the kind (packet, message, or
Address Block) and type of the TLV. For example, one TLV might
associate a lifetime to an address, another a content sequence number
to a message, and another a cryptographic signature to a packet. For
this reason, [RFC5444] specifies separate registries for Packet TLV
Types, Message TLV Types, and Address Block TLV Types, and it does
not specify any structure in the TLV Value field.

The TLVs defined in this document express, essentially, that "this
information will be refreshed within X seconds" and that "this
information is valid for X seconds after being received", each
allowing the "X seconds" to be specified as a function of the number
of hops from the originator of the information. This document
specifies a general format allowing expressing and encoding this as
the value field of a TLV. This representation uses a compact (8-bit)
representation of time, as message size is an issue in many MANETs,
and the offered precision and range is appropriate for MANET routing
protocols.

A TLV of this format may be used for packets, messages, or addresses.
For example, a proactive MANET routing protocol periodically
reporting link-state information could include a TLV of this format
as a Message TLV. This may indicate a different periodicity in
different scopes (possibly frequently up to a few hops, less
frequently beyond that) because some messages may be sent with
limited scope, as specified in [RFC5444]. A reactive MANET routing
protocol could include a TLV of this format as an Address Block TLV
for reporting the lifetime of routes to individual addresses.

In addition to defining the general format as outlined above, this
document requests IANA assignments for INTERVAL_TIME and
VALIDITY_TIME TLVs. These IANA assignments are requested in this
document in order to avoid interdependencies between otherwise
unrelated MANET protocols and in order to not exhaust the TLV Type
spaces by having different protocols request types for essentially
identical data structures. Only Message TLVs and Address Block TLVs
are requested, as these are those for which a need has been
demonstrated.

2. Terminology

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT",
"SHOULD", "SHOULD NOT", "RECOMMENDED", "NOT RECOMMENDED", "MAY", and
"OPTIONAL" in this document are to be interpreted as described in
[RFC2119].

Additionally, this document uses terminology from [RFC5444], and
introduces the following terminology:

hop count - the number of hops from the message originator to the
   message recipient. This is defined to equal the <msg-hop-count>
   field in the <msg-header> element defined in [RFC5444], if
   present, after it is incremented on reception. If the <msg-hop-
   count> field is not present, or in a Packet TLV, then hop count is
   defined to equal 255.

      time-value - a time, measured in seconds.

      time-code - an 8-bit field, representing a time-value.

3. Applicability Statement

   The TLV structure described in this document is applicable whenever a
   single time-value, or a time-value that varies with the number of
   hops from the originator of a message, is required in a protocol
   using the generalized MANET packet/message format [RFC5444].

   Examples of time-values that may be included in a protocol message
   are:

   o The maximum time interval until the next message of the same type
      is to be generated by the message's originator node.

   o The validity time of the information with which the time-value is
      associated.

   Either of these may vary with the hop count between the originating
   and receiving nodes, e.g., if messages of the same type are sent with
   different hop limits as defined in [RFC5444].

   Parts of this document have been generalized from material in the
   proactive MANET routing protocol OLSR (Optimized Link State Routing
   Protocol) [RFC3626].

4. Protocol Overview and Functioning

   This document does not specify a protocol nor does it mandate
   specific node or protocol behavior. Rather, it outlines mechanisms
   for encoding time-values using the TLV mechanism of [RFC5444].

5. Representing Time

   This document specifies a TLV structure in which time-values are each
   represented in an 8-bit time-code, one or more of which may be used
   in a TLV's <value> field. Of these 8 bits, the least significant 3
   bits represent the mantissa (a), and the most significant 5 bits
   represent the exponent (b), so that:

   o time-value := (1 + a/8) * 2^b * C

   o time-code := 8 * b + a

All nodes in the MANET MUST use the same value of the constant C,
which will be specified in seconds, hence so will be all time-values.
C MUST be greater than 0 seconds. Note that ascending values of the
time-code represent ascending time-values; time-values may thus be
compared by comparison of time-codes.

An algorithm for computing the time-code representing the smallest
representable time-value not less than the time-value t is:

1. find the largest integer b such that t/C >= 2^b;

2. set a := 8 * (t / (C * 2^b) - 1), rounded up to the nearest
    integer;

3. if a = 8, then set b := b + 1 and set a := 0;

4. if 0 <= a <= 7, and 0 <= b <= 31, then the required time-value
    can be represented by the time-code 8 * b + a, otherwise it
    cannot.

The minimum time-value that can be represented in this manner is C.
The maximum time-value that can be represented in this manner is 15 *
2^28 * C, or about 4.0 * 10^9 * C. If, for example, C = 1/1024
second, then this is about 45 days.

A protocol using this time representation MUST define the value of C.
A protocol using this specification MAY specify that the all-bits
zero time-value (0) represents a time-value of zero and/or that the
all-bits one time-value (255) represents an indefinitely large time-
value.

6. General Time TLV Structure

The following data structure allows the representation of a single
time-value, or of a default time-value plus pairs of (time-values,
hop counts) for when hop-count-dependent time-values are required.
The time-values are represented as time-codes as defined in
Section 5. This <time-data> data structure is specified, using the
regular expression syntax of [RFC5444], by:

    <time-data> = (<time-code><hop-count>)*<time-code>

where:

<time-code> is an 8-bit unsigned integer field containing a time-
   code as defined in Section 5.

   <hop-count> is an 8-bit unsigned integer field specifying a hop
      count from the message originator.

   A <time-data> structure thus consists of an odd number of octets;
   with a repetition factor of n for the (time, hop count) pairs in the
   regular expression syntax, it contains 2n+1 octets. On reception, n
   is determined from the length.

   A <time-data> field may be thus represented by:

       <t_1><d_1><t_2><d_2> ... <t_i><d_i> ... <t_n><d_n><t_default>

   <d_1>, ... <d_n>, if present, MUST be a strictly increasing sequence,
   with <d_n> < 255. Then, at the receiving node's hop count from the
   originator node, the time-value indicated is that represented by the
   time-code:

   o <t_1>, if n > 0 and hop count <= <d_1>;

   o <t_i+1>, if n > 1 and <d_i> < hop count <= <d_i+1> for some i such
      that 1 <= i < n;

   o <t_default> otherwise, i.e. if n = 0 or hop count > <d_n>.

   If included in a message without a <msg-hop-count> field in its
   Message Header, or in a Packet TLV, then the form of this data
   structure with a single time-code in <time-data> (i.e., n = 0) SHOULD
   be used.

6.1. Single-Value Time TLVs

   The purpose of a single value Time TLV is to allow a single time-
   value to be determined by a node receiving an entity containing the
   Time TLV, based on its hop count from the entity's originator. The
   Time TLV may contain information that allows that time-value to be a
   function of the hop count; thus, different receiving nodes may
   determine different time-values.

   A single-value Time TLV may be a Packet TLV, a Message TLV, or an
   Address Block TLV.

   A Time TLV that has the tismultivalue flag cleared ('0') in its <tlv-
   flags> field, as defined in [RFC5444], contains a single <time-data>,
   as defined above, in its <value> field. For such a Time TLV:

   o The <length> field in the TLV MUST contain the value 2n+1, with n
      being the number of (time-value, hop count) pairs in the Time TLV.

o The number of (time-value, hop count) pairs MUST be identified by
   inspecting the <length> field in the TLV. The number of such
   pairs, n, is:

   * n := (<length> - 1) / 2

   This MUST be an integer value.

6.2. Multi-Value Time TLVs

   The purpose of a multi-value Time TLV is to associate a set of <time-
   data> structures to an identically sized set of addresses, as
   described in [RFC5444]. For each of these <time-data> structures, a
   single time-value can be determined by a node receiving an entity
   containing the Time TLV, based on its hop count from the entity's
   originator. The Time TLV may contain information that allows that
   time-value to be a function of the hop count, and thus different
   receiving nodes may determine different time-values.

   Multi-value Time TLVs MUST be Address Block TLVs. A multi-value Time
   TLV MUST NOT be a Packet TLV or Message TLV.

   A Time TLV that has the tismultivalue flag set ('1') in its <tlv-
   flags> field, as defined in [RFC5444], contains a sequence of <time-
   data> structures, as defined above, in its <value> field. For such a
   Time TLV:

   o The <length> field in the TLV MUST contain the value m * (2n+1),
      with n being the number of (time-value, hop count) pairs in the
      Time TLV, and m being number-values as defined in [RFC5444].

   o The number of <time-data> structures included in the <value> field
      is equal to number-values as defined in [RFC5444].

   o The number of (time-value, hop count) pairs in each <time-data>
      structure MUST be the same, and MUST be identified by inspecting
      the <length> field in the TLV and using number-values as defined
      in [RFC5444]. The number of such pairs in each <time-data>
      structure, n, is:

      * n := ((<length> / number-values) - 1) / 2

      This MUST be an integer value. The lists of hop count values MAY
      be different.

7. Message TLVs

   Two Message TLVs are defined, for signaling message interval
   (INTERVAL_TIME) and message validity time (VALIDITY_TIME).

7.1. INTERVAL_TIME TLV

   An INTERVAL_TIME TLV is a Message TLV that defines the maximum time
   before another message of the same type as this message from the same
   originator should be received. This interval time MAY be specified
   to depend on the hop count from the originator. (This is appropriate
   if messages are sent with different hop limits so that receiving
   nodes at greater hop counts have an increased interval time.)

   A message MUST NOT include more than one INTERVAL_TIME TLV.

   An INTERVAL_TIME TLV is an example of a Time TLV specified as in
   Section 5.

7.2. VALIDITY_TIME TLV

   A VALIDITY_TIME TLV is a Message TLV that defines the validity time
   of the information carried in the message in which the TLV is
   contained. After this time, the receiving node MUST consider the
   message content to no longer be valid (unless repeated in a later
   message). The validity time of a message MAY be specified to depend
   on the hop count from its originator. (This is appropriate if
   messages are sent with different hop limits so that receiving nodes
   at greater hop counts receive information less frequently and must
   treat is as valid for longer.)

   A message MUST NOT include more than one VALIDITY_TIME TLV.

   A VALIDITY_TIME TLV is an example of a Time TLV specified as in
   Section 5.

8. Address Block TLVs

   Two Address Block TLVs are defined, for signaling address
   advertisement interval (INTERVAL_TIME) and address validity time
   (VALIDITY_TIME).

8.1. INTERVAL_TIME TLV

   An INTERVAL_TIME TLV is an Address Block TLV that defines the maximum
   time before this address from the same originator should be received
   again. This interval time MAY be specified to depend on the hop
   count from the originator. (This is appropriate if addresses are

   contained in messages sent with different hop limits so that
   receiving nodes at greater hop counts have an increased interval
   time.)

   A protocol using this TLV and the same named Message TLV MUST specify
   how to interpret the case when both are present (typically, that the
   former overrides the latter for those addresses that are covered by
   the former).

   An INTERVAL_TIME TLV is an example of a Time TLV specified as in
   Section 5.

8.2. VALIDITY_TIME TLV

   A VALIDITY_TIME TLV is an Address Block TLV that defines the validity
   time of the addresses to which the TLV is associated. After this
   time, the receiving node MUST consider the addresses to no longer be
   valid (unless these are repeated in a later message). The validity
   time of an address MAY be specified to depend on the hop count from
   its originator. (This is appropriate if addresses are contained in
   messages sent with different hop limits so that receiving nodes at
   greater hop counts receive information less frequently and must treat
   is as valid for longer.)

   A protocol using this TLV and the same named Message TLV MUST specify
   how to interpret the case when both are present (typically, that the
   former overrides the latter for those addresses that are covered by
   the former).

   A VALIDITY_TIME TLV is an example of a Time TLV specified as in
   Section 5.

9. IANA Considerations

   This specification defines two Message TLV Types, which have been
   allocated from the "Assigned Message TLV Types" repository of
   [RFC5444] as specified in Table 1, and two Address Block TLV Types,
   which have been allocated from the "Assigned Address Block TLV Types"
   repository of [RFC5444] as specified in Table 2.

   IANA has assigned the same numerical value to the Message TLV Type
   and Address Block TLV Type with the same name.

9.1. Expert Review: Evaluation Guidelines

   For the registries for TLV Type Extensions where an Expert Review is
   required, the designated expert SHOULD take the same general
   recommendations into consideration as are specified by [RFC5444].

9.2. Message TLV Types

```
+---------------+------+-----------+------------------------------+
|     Name      | Type |   Type    | Description                  |
|               |      | Extension |                              |
+---------------+------+-----------+------------------------------+
| INTERVAL_TIME |  0   |     0     | The maximum time before      |
|               |      |           | another message of the same  |
|               |      |           | type as this message from the|
|               |      |           | same originator should be    |
|               |      |           | received                     |
|   Unassigned  |  0   |   1-223   | Expert Review                |
|               |      |  224-255  | Experimental Use             |
| VALIDITY_TIME |  1   |     0     | The time from receipt of the |
|               |      |           | message during which the     |
|               |      |           | information contained in the |
|               |      |           | message is to be considered  |
|               |      |           | valid                        |
|   Unassigned  |  1   |   1-223   | Expert Review                |
|               |      |  224-255  | Experimental Use             |
+---------------+------+-----------+------------------------------+
```

Table 1

9.3. Address Block TLV Types

```
+---------------+------+-----------+------------------------------+
|     Name      | Type |   Type    | Description                  |
|               |      | extension |                              |
+---------------+------+-----------+------------------------------+
| INTERVAL_TIME |  0   |     0     | The maximum time before      |
|               |      |           | another message of the same  |
|               |      |           | type as this message from the|
|               |      |           | same originator and containing|
|               |      |           | this address should be       |
|               |      |           | received                     |
|   Unassigned  |  0   |   1-223   | Expert Review                |
|               |      |  224-255  | Experimental Use             |
| VALIDITY_TIME |  1   |     0     | The time from receipt of the |
|               |      |           | address during which the     |
|               |      |           | information regarding this    |
|               |      |           | address is to be considered  |
|               |      |           | valid                        |
|   Unassigned  |  0   |   1-223   | Expert Review                |
|               |      |  224-255  | Experimental Use             |
+---------------+------+-----------+------------------------------+
```

Table 2

10. Security Considerations

   This document specifies how to add data structures (TLVs) that
   provide timing information to packets and messages specified using
   [RFC5444]. In particular, information validity durations and
   reporting intervals may be added.

   The general security threats that apply are those general to
   [RFC5444] and described therein, problems of integrity and
   confidentiality. With regard to the former, modification of a Time
   TLV can cause information to have an invalid validity time, or
   expected interval time. This may cause incorrect protocol
   performance. Modification or addition of timed information can add
   to a protocol's workload (especially if a short validity time is
   specified) and storage requirements (especially if a long validity
   time is specified).

   To counter these threats, the security suggestions in [RFC5444], for
   the use of authentication and encryption, are appropriate.

11. References

11.1. Normative References

   [RFC2119] Bradner, S., "Key words for use in RFCs to Indicate
              Requirement Levels", BCP 14, RFC 2119, March 1997.

   [RFC5444] Clausen, T., Dearlove, C., Dean, J., and C. Adjih,
              "Generalized Mobile Ad Hoc Network (MANET) Packet/Message
              Format", RFC 5444, February 2009.

11.2. Informative References

   [RFC3626] Clausen, T. and P. Jacquet, "The Optimized Link State
              Routing Protocol", RFC 3626, October 2003.

Appendix A. Acknowledgements

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Authors' Addresses

   Thomas Heide Clausen
   LIX, Ecole Polytechnique, France

   Phone: +33 6 6058 9349
   EMail: T.Clausen@computer.org
   URI: http://www.ThomasClausen.org/

   Christopher Dearlove
   BAE Systems Advanced Technology Centre

   Phone: +44 1245 242194
   EMail: chris.dearlove@baesystems.com
   URI: http://www.baesystems.com/