RFC7722: Multi-Topology Extension for the Optimized Link State Routing Protocol Version 2 (OLSRv2)

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                        Multi-Topology Extension
    for the Optimized Link State Routing Protocol Version 2 (OLSRv2)

Abstract

   This specification describes an extension to the Optimized Link State
   Routing Protocol version 2 (OLSRv2) to support multiple routing
   topologies, while retaining interoperability with OLSRv2 routers that
   do not implement this extension.

   This specification updates RFCs 7188 and 7631 by modifying and
   extending TLV registries and descriptions.

Status of This Memo

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1. Introduction

   The Optimized Link State Routing Protocol version 2 [RFC7181]
   (OLSRv2) is a proactive link state routing protocol designed for use
   in Mobile Ad Hoc Networks (MANETs) [RFC2501]. One of the significant
   improvements of OLSRv2 over its Experimental precursor [RFC3626] is
   the ability of OLSRv2 to use link metrics to select routes other than
   minimum hop routes.

   A limitation that remains in OLSRv2 is that it uses a single link
   metric type for all routes. However, in some MANETs it would be
   desirable to be able to route packets using more than one link metric
   type. This specification describes an extension to OLSRv2 that is
   designed to permit this, while maintaining maximal interoperability
   with OLSRv2 routers not implementing this extension.

   The purpose of OLSRv2 can be described as to create and maintain a
   Routing Set, which contains all the necessary information to populate
   an IP routing table. In a similar way, the role of this extension
   can be described as to create and maintain multiple Routing Sets, one
   for each link metric type supported by the router maintaining the
   sets.

1.1. Motivation and Experimentation

   Multi-topology routing is a natural extension to a link state routing
   protocol, such as OSPF (see [RFC4915]). However multi-topology
   routing for OLSRv2 does not yet benefit from extensive operational,
   or even experimental, experience. This specification is published to
   facilitate collecting such experience, with the intent that once
   suitable experimental evidence has been collected, an OLSRv2 Multi-
   Topology Routing Extension will be proposed for advancement onto the
   Standards Track.

   Any experiments using this protocol extension are encouraged.
   Reports from such experiments planned with pre-specified objectives
   and scenarios (including link, position, and mobility information)
   are particularly encouraged. Results from such experiments,
   documenting the following, are of particular importance:

   o Operation in networks that contain both routers implementing this
      extension and routers implementing only [RFC7181]. In particular,
      are there any unexpected interactions that can break the network?

   o Operation in networks with dynamic topologies, both due to
      mobility and due to link metric changes for reasons other than
      mobility.

   o Operation in realistic deployments, and details thereof, including
      how many concurrent topologies were required.

   o Behavior of Routing Sets, including measures of successful route
      establishment.

   In addition, reports from experiments covering the following are also
   of value:

   o Which link metric types were useful, and how the metrics to
      associate with a given link were established.

   o How packet types were associated with link metric types (whether
      using Diffserv or an alternative mechanism).

   o Any data link-layer issues, and any cross-layer issues, including
      whether and how Neighborhood Discovery Protocol (NHDP) link
      quality was used.

   o Transport- and higher-layer issues observed, if any.

   o Resource requirements observed from running the protocol,
      including processing, storage, and bandwidth.

   o Network performance, including packet delivery results.

   o Any other implementation issues.

   The first bullet in the list directly above applies to unextended
   OLSRv2 [RFC7181] as well as with this extension, and potentially to
   other MANET routing protocols. This specification also allows
   experimentation with link metric types that are not compromises for
   handling multiple traffic types.

2. Terminology and Notation

   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].

   This specification uses the terminology of [RFC5444], [RFC6130], and
   [RFC7181], which is to be interpreted as described in those
   specifications.

   Additionally, this specification uses the following terminology:

   Router - A MANET router that implements [RFC7181].

   MT-OLSRv2 - The protocol defined in this specification as an
      extension to OLSRv2 [RFC7181].

   This specification introduces the notation map[A -> B] to represent
   an associative mapping. The domain of this mapping (A) is, in this
   specification, always a set of link metric types that the router
   supports: either IFACE_METRIC_TYPES or ROUTER_METRIC_TYPES, as
   defined in Section 5. The codomain of this mapping (B) is a set of
   all possible values of an appropriate type. In this specification,
   this type is always one of:

   o boolean (true or false),

   o willingness (a 4-bit unsigned integer from 0 to 15),

   o number of hops (an 8-bit unsigned integer from 0 to 255), or

   o link metric (either a representable link metric value, as
      described in [RFC7181], or UNKNOWN_METRIC).

3. Applicability Statement

   The protocol described in this specification is applicable to a MANET
   for which OLSRv2 is otherwise applicable (see [RFC7181], Section 3),
   but in which multiple topologies are maintained, each characterized
   by a different choice of link metric type. It is assumed, but
   outside the scope of this specification, that the network layer is
   able to choose which topology to use for each packet, for example,
   using the Diffserv Code Point (DSCP) defined in [RFC2474]. This
   selection of topology MUST be consistent; that is, each router
   receiving a packet must make the same choice of link metric type, in
   order that each packet uses a single topology. This is necessary to
   avoid the possibility of a packet "looping" in the network.

4. Protocol Overview and Functioning

   The purpose of this specification is to extend OLSRv2 [RFC7181] so as
   to enable a router to establish and maintain multiple routing
   topologies in a MANET, each topology associated with a link metric
   type. Routers in the MANET may each form part of some or all of
   these topologies, and each router will maintain a Routing Set for
   each topology that it forms part of, allowing separate routing of
   packets for each topology.

   MT-OLSRv2 is designed to interoperate with OLSRv2; a MANET can be
   created containing both routers that implement MT-OLSRv2 (MT-OLSRv2
   routers) and routers that do not implement MT-OLSRv2 and may be
   unaware of its existence (non-MT-OLSRv2 routers). MANETs may also be

created that are known to contain only MT-OLSRv2 routers. In both
cases, but especially where a MANET contains both MT-OLSRv2 routers
and non-MT-OLSRv2 routers, management may be required to ensure that
the MANET will function as required, and will not, for example,
unnecessarily fragment. (Such issues already arise in an
OLSRv2-based MANET using multiple interfaces.)

OLSRv2 is an extension of NHDP [RFC6130]. However, the extension in
this specification does not modify NHDP, it only modifies Protocol
Sets that are specific to OLSRv2, or elements in Protocol Tuples that
were added by OLSRv2 and that are neither included in nor used by
NHDP. In addition it does not use or modify the link quality
mechanism in [RFC6130].

Each router implementing this specification selects a set of link
metric types for each of its OLSRv2 interfaces. If all routers in
the MANET implement MT-OLSRv2, then there are no restrictions within
this specification on how these sets of link metrics are selected.
(However, the issues described in the preceding paragraph still
apply.) On the other hand, in MANETs containing non-MT-OLSRv2
routers, the single link metric used by these non-MT-OLSRv2 routers
must be included in the set of link metrics for each OLSRv2 interface
of an MT-OLSRv2 router that may be heard on an OLSRv2 interface of a
non-MT-OLSRv2 router in the MANET.

Each router then determines an incoming link metric for each link
metric type selected for each of its OLSRv2 interfaces. These link
metrics are distributed using link metric TLVs contained in all HELLO
messages sent on OLSRv2 interfaces and in all TC messages. Unless
using only the single metric type used by non-MT-OLSRv2 routers, both
HELLO and TC messages generated by an MT-OLSRv2 router include an
MPR_TYPES Message TLV that indicates that this is an MT-OLSRv2 router
and which metric types it supports (on the sending OLSRv2 interface
for a HELLO message).

An MT-OLSRv2 router maintains, for each supported neighbour metric
type and for each symmetric 1-hop neighbor, the following:

    o link and neighbour metric values,

    o routing MPR status,

    o routing MPR selector status, and

    o advertised neighbour status.

Each router may choose a different willingness to be a routing MPR
for each link metric type that it supports.

A network using MT-OLSRv2 will usually require greater management
than one using unmodified OLSRv2. In particular, the use of multiple
metric types across the MANET must be managed, by administrative
configuration or otherwise. As also for other decisions that may be
made when using OLSRv2, a bad collective choice of metric type use
will make the MANET anywhere from inefficient to nonfunctional, so
care will be needed in selecting supported link metric types across
the MANET.

The meanings of link metric types are at the discretion of the MANET
operator. They could be used, for example, to represent packets of
different types, packets in streams of different rates, or packets
with different trust requirements. Note that packets will generally
not be delivered to routers that do not support that link metric
type, and the MANET, and the packets sent in it, will need to be
managed accordingly (especially if the MANET contains any
non-MT-OLSRv2 routers).

5. Parameters

   The parameters used in [RFC7181], and in its normative references,
   are used in this specification with the following changes.

   Each OLSRv2 interface will support a number of link metric types,
   corresponding to Type Extensions of the LINK_METRIC TLV defined in
   [RFC7181]. The router parameter LINK_METRIC_TYPE, used by routers
   that do not implement MT-OLSRv2, and used with that definition in
   this specification, is replaced in routers implementing MT-OLSRv2 by
   an interface parameter array IFACE_METRIC_TYPES and a router
   parameter array ROUTER_METRIC_TYPES. Each element in these arrays is
   a link metric type (i.e., a type extension used by the LINK_METRIC
   TLV [RFC7181]).

   The interface parameter array IFACE_METRIC_TYPES contains the link
   metric types supported on that OLSRv2 interface. The router
   parameter array ROUTER_METRIC_TYPES is the union of all of the
   IFACE_METRIC_TYPES. Both arrays MUST be without repetitions.

   If in a given deployment there might be routers that do not implement
   MT-OLSRv2, then IFACE_METRIC_TYPES MUST include LINK_METRIC_TYPE as
   its first element, so that the OLSRv2 interface can communicate with
   those routers. In that case, ROUTER_METRIC_TYPES MUST also include
   LINK_METRIC_TYPE as its first element.

   In addition, the router parameter WILL_ROUTING is extended to an
   array of values, one each for each link metric type in the router
   parameter list ROUTER_METRIC_TYPES.

6. Information Bases

   The Information Bases specified in [RFC7181], which extend those
   specified in [RFC6130], are further extended in this specification.
   With the exception of the Routing Set, the extensions in this
   specification are the replacement of single values (boolean,
   willingness, number of hops, or link metric) from [RFC7181] with
   elements representing multiple values (associative mappings from a
   set of metric types to their corresponding values). The following
   subsections detail these extensions.

   Note that, as in [RFC7181], an implementation is free to organize its
   internal data in any manner it chooses; it needs only to behave as if
   it were organized as described in [RFC7181] and this specification.

6.1. Local Attached Network Set

   Each element AL_dist becomes a map[ROUTER_METRIC_TYPES -> number of
   hops].

   Each element AL_metric becomes a map[ROUTER_METRIC_TYPES -> link
   metric].

6.2. Link Sets

   Each element L_in_metric becomes a map[IFACE_METRIC_TYPES -> link
   metric].

   Each element L_out_metric becomes a map[IFACE_METRIC_TYPES -> link
   metric].

   The elements of L_in_metric MUST be set following the same rules that
   apply to the setting of the single element L_in_metric in [RFC7181].

6.3. 2-Hop Sets

   Each element N2_in_metric becomes a map[ROUTER_METRIC_TYPES -> link
   metric].

   Each element N2_out_metric becomes a map[ROUTER_METRIC_TYPES -> link
   metric].

6.4. Neighbor Set

   Each element N_in_metric becomes a map[ROUTER_METRIC_TYPES -> link
   metric].

Each element N_out_metric becomes a map[ROUTER_METRIC_TYPES -> link metric].

Each element N_will_routing becomes a map[ROUTER_METRIC_TYPES -> willingness].

Each element N_routing_mpr becomes a map[ROUTER_METRIC_TYPES -> boolean].

Each element N_mpr_selector becomes a map[ROUTER_METRIC_TYPES -> boolean].

Each element N_advertised becomes a map[ROUTER_METRIC_TYPES -> boolean].

6.5. Router Topology Set

Each element TR_metric becomes a map[ROUTER_METRIC_TYPES -> link metric].

Note that some values of TR_metric may now take the value UNKNOWN_METRIC. When used to construct a Routing Set, where just the corresponding link metric value from this mapping is used, Router Topology Tuples whose corresponding value from TR_metric is UNKNOWN_METRIC are ignored.

6.6. Routable Address Topology Set

Each element TA_metric becomes a map[ROUTER_METRIC_TYPES -> link metric].

Note that some values of TA_metric may now take the value UNKNOWN_METRIC. When used to construct a Routing Set, where just the corresponding link metric value from this mapping is used, Routable Address Topology Tuples whose corresponding value from TA_metric is UNKNOWN_METRIC are ignored.

6.7. Attached Network Set

Each element AN_dist becomes a map[ROUTER_METRIC_TYPES -> number of hops].

Each element AN_metric becomes a map[ROUTER_METRIC_TYPES -> link metric].

Note that some values of AN_metric may now take the value UNKNOWN_METRIC. When used to construct a Routing Set, where just the corresponding link metric value from this mapping is used, Attached

Network Tuples whose corresponding value from AN_metric is
UNKNOWN_METRIC are ignored.

6.8. Routing Sets

   There is a separate Routing Set for each link metric type in
   ROUTER_METRIC_TYPES.

7. TLVs

   This specification makes the following additions and extensions to
   the TLVs defined in [RFC7181].

7.1. Message TLVs

   One new Message TLV is defined in this specification, and one
   existing Message TLV is extended by this specification.

7.1.1. MPR_TYPES TLV

   The MPR_TYPES TLV is used in both HELLO messages sent over OLSRv2
   interfaces and TC messages. A message MUST NOT contain more than one
   MPR_TYPES TLV.

   The presence of this TLV in a message is used to indicate that the
   router supports MT-OLSRv2, in the same way that the presence of the
   MPR_WILLING TLV is used to indicate that the router supports OLSRv2,
   as specified in [RFC7181]. For this reason, the MPR_TYPES TLV has
   been defined with the same Type as the MPR_WILLING TLV, but with Type
   Extension = 1.

   This TLV may take a Value field of any size. Each octet in its Value
   field will contain a link metric type that is supported, either on
   any OLSRv2 interface, when included in a TC message, or on the OLSRv2
   interface on which a HELLO message including this TLV is sent. These
   octets MAY be in any order, but if there might be routers in the
   MANET that do not implement MT-OLSRv2, then the first octet MUST be
   LINK_METRIC_TYPE.

7.1.2. MPR_WILLING TLV

   The MPR_WILLING TLV, which is used in HELLO messages, is specified in
   [RFC7181], and extended in this specification as enabled by
   [RFC7188].

   The interpretation of this TLV, which is specified by [RFC7181] and
   uses all of its single-octet Value field, is unchanged. That
   interpretation uses bits 0-3 of its Value field to specify its

willingness to be a flooding TLV, and bits 4-7 of its Value field to
be a routing TLV. Those latter bits are, when using this
specification, interpreted as its willingness to be a routing TLV
using the link metric type LINK_METRIC_TYPE.

The extended use of this message TLV, as defined by this
specification, defines additional 4-bit sub-fields of the Value
field, starting with bits 4-7 of the first octet and continuing with
bits 0-3 of the second octet, to represent willingness to be a
routing MPR using the link metric types specified in this OLSRv2
interface's IFACE_METRIC_TYPES parameter, ordered as reported in the
included MPR_TYPES Message TLV. Note that this means that, if there
might be any non-MT-OLSRv2 routers, then the link metric type
LINK_METRIC_TYPE will continue to occupy bits 4-7 of the first octet.
(If there is no such TLV included, then the router does not support
MT-OLSRv2, and only the first octet of the Value field will be used.)

If the number of link metric types in this OLSRv2 interface's
IFACE_METRIC_TYPES parameter is even, then there will be an unused
4-bit sub-field in bits 4-7 of the last octet of a full-sized Value
field. These bits will not be used; they SHOULD all be cleared ('0')
on transmission and MUST be ignored on receipt.

If the Value field in an MPR_WILLING TLV is shorter than its full
length, then, as specified in [RFC7188], missing Value octets, i.e.,
missing willingness values, are considered as zero (WILL_NEVER).
This is the correct behavior. (In particular, it means that an
OLSRv2 router that is not implementing MT-OLSRv2 will not act as a
routing MPR for any link metric that it does not recognize.)

7.2. Address Block TLVs

   New Type Extensions are defined for the LINK_METRIC TLV defined in
   [RFC7181], and the Value fields of the MPR TLV and the GATEWAY TLV,
   both defined in [RFC7181], are extended, as enabled by [RFC7188].

7.2.1. LINK_METRIC TLV

   The LINK_METRIC TLV is used in HELLO messages and TC messages. This
   TLV is unchanged from the definition in [RFC7181].

   Only a single Type Extension was specified by [RFC7181] -- 0 for
   "Link metric meaning as assigned by administrative action". This
   specification extends it to the range 0-7. This specification will
   work with any combination of Type Extensions both within and outside
   that range (assuming that the latter are defined as specified in
   [RFC7181]).

7.2.2. MPR TLV

   The MPR TLV is used in HELLO messages and indicates that an address
   with which it is associated is of a symmetric 1-hop neighbor that has
   been selected as an MPR.

   The Value field of this address block TLV is, in [RFC7181], defined
   to be one octet long, with the values 1, 2, and 3 defined. [RFC7188]
   redefines this Value field to be a bitfield where bit 7 (the least
   significant bit) denotes flooding status, bit 6 denotes routing MPR
   status, and bits 5-0 are unallocated (respecting the semantics of the
   bits/values 1, 2, and 3 from [RFC7181]).

   This specification, as enabled by [RFC7188], extends the MPR TLV to
   have a variable-length Value field. Bits are allocated in increasing
   significance within as many octets as are required. These bits
   specify, in order, that:

   o The neighbor with that network address has been selected as
      flooding MPR (1 bit).

   o The neighbor with that network address has been selected as
      routing MPR for each link metric type (1 bit each), in the same
      order as indicated in the Value field of an MPR_TYPES Message TLV.

   For interoperability with a router not implementing MT-OLSRv2, the
   two least significant bits of the first octet in the Value field of
   this TLV is as the TLV Value of an MPR TLV generated according to
   [RFC7181], as updated by [RFC7188].

7.2.3. GATEWAY TLV

   The GATEWAY TLV is used in TC messages to indicate that a network
   address is of an attached network.

   The Value field of this address block TLV is defined by [RFC7181] to
   be one octet long, containing the number of hops to that attached
   network.

   This specification, as enabled by [RFC7188], allows the extension of
   the GATEWAY TLV to have a variable-length Value field when the number
   of hops to each attached network is different for different link
   metric types. For interoperability with a router not implementing
   MT-OLSRv2, the first octet in the Value field of this TLV MUST be the
   TLV Value of the GATEWAY TLV generated according to [RFC7181].

Any subsequent octets in the TLV Value field indicate the number of
hops to the attached network for each other link metric type. Link
metric types (including the first) are ordered as indicated in the
Value field of an MPR_TYPES Message TLV.

```
+---------+------------------------------------------------------------+
|  Type   | Value                                                      |
+---------+------------------------------------------------------------+
| GATEWAY | Number of hops to attached network for each link metric    |
|         | type.                                                      |
+---------+------------------------------------------------------------+
```

Table 1: GATEWAY TLV Definition

8. HELLO Messages

The following changes are made to the generation and processing of
HELLO messages compared to the description in [RFC7181] for routers
that implement MT-OLSRv2.

8.1. HELLO Message Generation

A generated HELLO message to be sent on an OLSRv2 interface (whose
IFACE_METRIC_TYPES parameter will be that used) is extended by:

o Adding an MPR_TYPES Message TLV. The Value octets will be the
   link metric types in IFACE_METRIC_TYPES. This TLV MAY be omitted
   if the only link metric type included would be LINK_METRIC_TYPE.

o Extending the MPR_WILLING Message TLV Value field to report the
   willingness values from the WILL_ROUTING parameter list that
   correspond to the link metric types in IFACE_METRIC_LIST, in the
   same order as reported in the MPR_TYPES TLV, each value (also
   including one representing WILL_FLOODING) occupying 4 bits.

o Including LINK_METRIC Address Block TLVs that report all values in
   L_in_metric, L_out_metric, N_in_metric, and N_out_metric elements
   that are not equal to UNKNOWN_METRIC, with the TLV Type Extension
   being the link metric type, and otherwise following the rules for
   such inclusions specified in [RFC7181].

o Including MPR Address Block TLVs such that for each link metric
   type in IFACE_METRIC_TYPES, and for the choice of flooding MPRs,
   the indicated addresses MUST be of the MPRs in an MPR set as
   specified for a single link metric type in [RFC7181].

8.2. HELLO Message Processing

   On receipt of a HELLO message on an OLSRv2 interface, a router
   implementing MT-OLSRv2 MUST do the following, in addition to the
   processing described in [RFC7181]:

   1. If in this deployment there might be routers that do not
       implement MT-OLSRv2, the HELLO message contains an MPR_TYPES
       Message TLV, and the first link metric type that it reports is
       not LINK_METRIC_TYPE, then the HELLO message MUST be silently
       discarded.

   2. Determine the list of link metric types supported by the sending
       router on its corresponding OLSRv2 interface, either from an
       MPR_TYPES Message TLV (if present) or from the single link metric
       type LINK_METRIC_TYPE.

   3. For all link metric types reported and supported by the receiving
       router, set the appropriate L_out_metric, N_in_metric,
       N_out_metric, N_will_routing, N_mpr_selector, N_advertised,
       N2_in_metric, and N2_out_metric elements using the rules for
       setting the single elements of those types specified in
       [RFC7181].

   4. For any other metric types supported by the receiving router only
       (i.e. in IFACE_METRIC for the receiving OLSRv2 interface), set
       the elements listed in the previous point to their default
       values, i.e., UNKNOWN_METRIC, WILL_NEVER (not WILL_DEFAULT), or
       false.

9. TC Messages

   The following changes are made to the generation and processing of TC
   messages compared to that described in [RFC7181] by routers that
   implement MT-OLSRv2.

9.1. TC Message Generation

   A generated TC message is extended by:

   o Adding an MPR_TYPES TLV. The Value octets will be the link metric
      types in ROUTER_METRIC_TYPES. This TLV MAY be omitted if the only
      link metric type included would be LINK_METRIC_TYPE.

   o Including LINK_METRIC TLVs that report all values of N_out_metric
      that are not equal to UNKNOWN_METRIC, with the TLV Type Extension
      being the link metric type, and otherwise following the rules for
      such inclusions specified in [RFC7181].

o Including a number of hops per reported (in an MPR_TYPES Message
   TLV) link metric type in the Value field of each GATEWAY TLV
   included, in the same order as reported in the MPR_TYPES TLV.

9.2. TC Message Processing

   On receipt of a TC message, a router implementing this extension MUST
   do the following, in addition to the processing specified in
   [RFC7181]:

   o If in this deployment there might be routers that do not implement
      MT-OLSRv2, the TC message contains an MPR_TYPES Message TLV, and
      the first link metric type that it reports is not
      LINK_METRIC_TYPE, then the TC message MUST be silently discarded.

   o For all link metric types reported and supported by the receiving
      router, set the appropriate TR_metric, TA_metric, AN_dist, and
      AN_metric elements using the rules for setting the single elements
      of those types specified in [RFC7181].

   o For any other metric types supported by the receiving router that
      do not have an advertised outgoing neighbor metric of that type,
      set the corresponding elements of TR_metric, TA_metric, and
      AN_metric to UNKNOWN_METRIC. (The corresponding element of
      AN_dist may be set to any value.)

10. MPR Calculation

   Routing MPRs are calculated for each link metric type in
   ROUTER_METRIC_TYPES. Links to symmetric 1-hop neighbors via OLSRv2
   interfaces that do not support that link metric type are not
   considered. The determined status (routing MPR or not routing MPR)
   for each link metric type is recorded in the relevant element of
   N_routing_mpr.

   Each router may make its own decision as to whether or not to use a
   link metric, or link metrics, for flooding MPR calculation. If using
   link metric(s), each router decides which one(s) and how they are
   used. These decisions MUST be made in a manner that ensures that
   flooded messages will reach the same symmetric 2-hop neighbors as
   would be the case for a router not supporting MT-OLSRv2.

   Note that it is possible that a 2-Hop Tuple in the Information Base
   for a given OLSRv2 interface does not support any of the link metric
   types that are in the router's corresponding IFACE_METRIC_TYPES;
   nevertheless, that 2-Hop Tuple MUST be considered when determining
   flooding MPRs.

11. Routing Set Calculation

   A Routing Set is calculated for each link metric type in
   ROUTER_METRIC_TYPES. The calculation may be as for [RFC7181], except
   that where an element is now represented by a map, the value from the
   map for the selected link metric type is used. Where this is a link
   metric of value UNKNOWN_METRIC, that protocol Tuple is ignored for
   the calculation.

12. Management Considerations

   MT-OLSRv2 may require greater management than unextended OLSRv2. In
   particular, a MANET using MT-OLSRv2 requires the following management
   considerations:

   o Deciding which link metric, and hence which Routing Set to use,
      for received packets, hence how to use the Routing Sets to
      configure the network layer (IP). All routers MUST make the same
      decision for the same packet. An obvious approach is to map each
      DSCP [RFC2474] to a single link metric. (This may be a many-to-
      one mapping.)

   o Selecting which link metrics to support on each OLSRv2 interface
      and implementing that decision. (Different interfaces may have
      different physical and data link-layer properties, and this may
      inform the selection of link metrics to support, and their
      values.) If the MANET might contain non-MT-OLSRv2 routers, which
      are also subject to management, then the rules in this
      specification for link metric assignment to OLSRv2 interfaces for
      that case MUST be followed.

   o Ensuring that the MANET is sufficiently connected, by ensuring
      that, for example, sufficiently many routers implement each metric
      type required. (This is easier in, for example, a denser network.)
      Note that if there is any possibility that there are routers not
      implementing MT-OLSRv2, then the MANET will be connected, to the
      maximum extent possible, using the link metric type
      LINK_METRIC_TYPE, but this will only serve to deliver packets that
      use that link metric type.

   o Non-MT-OLSRv2 routers SHOULD be managed so as not produce packets
      that will be routed by a topology that they are not part of.
      However, if that were to happen, then such packets will be routed
      until either they reach their destination or they reach an
      MT-OLSRv2 router. In the latter case, the packet then either will
      be dropped (if that MT-OLSRv2 router is not part of that topology,

or is not aware of the destination within that topology) or will
be routed by that topology to the destination. Such a packet will
not loop.

o If a packet is created for a destination that is not part of the
corresponding topology, then it may or may not be delivered (if
the originating router is a non-MT-OLSRv2 router) or will not be
sent (if the originating router is an MT-OLSRv2 router). Routers
SHOULD be managed so that topologies are as complete as possible
and that packets are not sent if they may not be delivered. In
particular, non-MT-OLSRv2 routers SHOULD only send packets that
will be routed using the topology using the link metric type
LINK_METRIC_TYPE.

13. IANA Considerations

This specification adds one new Message TLV, allocated as a new Type
Extension to an existing Message TLV, using a new name. It also
modifies the Value field of an existing Message TLV and that of an
existing Address Block TLV. Finally, this specification makes
additional allocations from the LINK_METRIC Address Block TLV Type
registry.

13.1. Expert Review: Evaluation Guidelines

For the registry where an Expert Review is required, the designated
expert SHOULD take the same general recommendations into
consideration as are specified by [RFC5444] and [RFC7631].

13.2. Message TLV Types

This specification modifies the Message TLV Type 7, replacing Table 4
of [RFC7631] by Table 2, changing the description of the Type
Extension MPR_WILLING, and adding the Type Extension TLV_TYPES. Each
of these TLVs MUST NOT be included more than once in a Message TLV
Block.

```
+-----------+------------+------------------------+---------------+
|   Type    |    Name    | Description            | Reference     |
| Extension |            |                        |               |
+-----------+------------+------------------------+---------------+
|     0     | MPR_WILLING| First (most            | [RFC7181]     |
|           |            | significant) half-octet| [RFC7631]     |
|           |            | of Value field         | RFC 7722      |
|           |            | specifies the          |               |
|           |            | originating router's   |               |
|           |            | willingness to act as a|               |
|           |            | flooding MPR;          |               |
|           |            | subsequent half-octets |               |
|           |            | specify the originating|               |
|           |            | router's willingness to|               |
|           |            | act as a routing MPR,  |               |
|           |            | either for the link    |               |
|           |            | metric types reported  |               |
|           |            | in an MPR_TYPES TLV (in |               |
|           |            | the same order), or (if|               |
|           |            | no MPR_TYPES TLV is     |               |
|           |            | present) for the single|               |
|           |            | administratively agreed|               |
|           |            | link metric type       |               |
|     1     | MPR_TYPES  | The link metric types  | RFC 7722      |
|           |            | supported on this      |               |
|           |            | OLSRv2 interface of    |               |
|           |            | this router (one octet |               |
|           |            | each).                 |               |
|   2-223   |            | Unassigned             |               |
|  224-255  |            | Reserved for           | [RFC7181]     |
|           |            | Experimental Use       |               |
+-----------+------------+------------------------+---------------+
```

Table 2: Type 7 Message TLV Type Extensions

13.3. Address Block TLV Types

   Table 7 of [RFC7188] is replaced by Table 3.

   +-------+-------+----------+--------------------------------------+
   | Bit | Value | Name | Description |
   +-------+-------+----------+--------------------------------------+
First	First	Flooding	If set, then the neighbor with that
octet	octet		network address has been selected as
bit 7	0x01		flooding MPR
From	From	Routing	If set, then the neighbor with that
first	first		network address has been selected as
octet	octet		routing MPR, either for the link
bit 6	0x02		metric types reported in an MPR_TYPES
			TLV (in the same order), or (if no
			MPR_TYPES TLV is present) then (first
			octet bit 6, value 0x02) for the
			single administratively agreed link
			metric type
   +-------+-------+----------+--------------------------------------+

                     Table 3: MPR TLV Bit Values

   Table 14 of [RFC7631] is replaced by Table 4. The only changes are
   to the Description and the References for the GATEWAY TLV.

   +-----------+---------+---------------------------+---------------+
   | Type | Name | Description | References |
   | Extension | | | |
   +-----------+---------+---------------------------+---------------+
0	GATEWAY	Specifies that a given	[RFC7181]
		network address is reached	RFC 7722
		via a gateway on the	
		originating router. The	
		number of hops is indicated	
		by the Value field, one	
		octet per link metric type	
		reported in an MPR_TYPES	
		Message TLV (in the same	
		order) or (if no MPR_TYPES	
		Message TLV is present)	
		using a single octet	
1-223		Unassigned	
224-255		Reserved for Experimental	[RFC7631]
		Use	
   +-----------+---------+---------------------------+---------------+

            Table 4: Type 10 Address Block TLV Type Extensions

Table 13 of [RFC7181] is replaced by Table 5. The only change is
that 8 Type Extensions are allocated as assigned by administrative
action, in order to support administratively determined multi-
topologies.

```
+-------------+------+-----------+------------------+--------------+
|    Name     | Type |   Type    | Description      | Allocation   |
|             |      | Extension |                  | Policy       |
+-------------+------+-----------+------------------+--------------+
| LINK_METRIC |  7   |    0-7    | Link metric      |              |
|             |      |           | meaning assigned |              |
|             |      |           | by administrative|              |
|             |      |           | action.          |              |
| LINK_METRIC |  7   |   8-223   | Unassigned.      | Expert       |
|             |      |           |                  | Review       |
| LINK_METRIC |  7   |  224-255  | Unassigned.      | Experimental |
|             |      |           |                  | Use          |
+-------------+------+-----------+------------------+--------------+
```

Table 5: Address Block TLV Type assignment: LINK_METRIC

14. Security Considerations

   This extension to OLSRv2 allows a router to support more than one
   link metric type for each link advertised in HELLO and TC messages,
   and for routers to support different sets of types. Link metric
   values of additional types are reported by the inclusion of
   additional TLVs in the messages sent by a router, which will report
   known values of all supported types.

   HELLO and TC message processing is then extended simply to record,
   for each supported type, all of the received link metric values for
   each link. Protocol-internal processing (specifically, MPR set and
   shortest path calculations) then operates as specified in [RFC7181]
   for each link metric type that the router supports.

   Consequently, the security considerations, including the security
   architecture and the mandatory security mechanisms, from [RFC7181]
   are directly applicable to MT-OLSRv2.

   Furthermore, this extension does not introduce any additional
   vulnerabilities beyond those of [RFC7181], because each link metric
   type is used independently, and each one could have been the single
   link metric type supported by an implementation of [RFC7181]
   receiving the same information, as received information of an
   unsupported type is ignored by all routers.

15. References

15.1. Normative References

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