Network Working Group P. Psenak
Internet-Draft S. Mirtorabi
Expires: October 22, 2005 A. Roy
L. Nguyen
P. Pillay-Esnault
Cisco Systems
April 20, 2005

Multi-Topology (MT) Routing in OSPF
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Abstract

This draft describes an extension to OSPF in order to define independent IP topologies called Multi-Topologies (MTs). The MT extension can be used for computing different paths for unicast traffic, multicast traffic, different classes of service based on flexible criteria, or an in-band network management topology.

[M-ISIS] describes a similar mechanism for ISIS.

An optional extension to exclude selected links from the default topology is also described.

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1. Introduction

OSPF uses a fixed packet format, therefore it is not easy to introduce any backward compatible extensions. However, the OSPF specification [OSPF] introduced TOS metric in an earlier specification [RFC1583] in order to announce a different link cost based on TOS. TOS based routing as described in [RFC1583] was never deployed and was subsequently deprecated.

We propose to reuse the TOS based metric fields. They have been redefined as MT-ID and MT-ID Metric and are used to advertise different topologies by advertising separate metrics for each of them.

1.1 Differences with RFC 1583 TOS Based Routing

Multi-topology routing differs from RFC 1583 TOS based routing in the following ways:

1. With RFC 1583 TOS routing, the TOS or DSCP in the IP header is mapped directly to the the corresponding OSPF SPF calculation and routing table. This limits the number and definition of the topologies to the 16 TOS values specified is section 12.3 of RFC 1583 [RFC1583]. With multi-topology routing, the classification of what type of traffic maps to which topology is not within the scope of the document.

2. With RFC 1583 TOS routing, traffic which is unreachable in the routing table associated with the corresponding TOS will revert to the TOS 0 routing table. With multi-topology routing, this is optional.

3. With RFC 1583 TOS routing, individual links or prefixes could not be excluded from a topology. If the LSA options T-bit was set, all links or prefixes were either advertised explicitly or defaulted to the TOS 0 metric. With multi-topology routing, links or prefixes that are not advertised for a specific topology do not exist in that topology.

2. Terminology

2.1 Requirements notation

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 RFC2119 [RFC2119].

2.2 Terms

We define the following terminology in this document:

Non-MT router
   Routers that do not have the MT capability

MT router
   Routers that have MT capability as described in this document

MT-ID
   Renamed TOS field in LSAs to represent multitopology ID.

Default topology
   Topology that is built using the TOS 0 metric (default metric)

MT topology
   Topology that is built using the corresponding MT-ID metric

MT
   Shorthand notation for MT topology

MT#0 topology
   Representation of TOS 0 metric in MT-ID format

Non-MT-Area
   An area that contains only non-MT routers

MT-Area
   An area that contains both non-MT routers and MT routers or only MT routers

3. Base MT Functional Specifications

3.1 MT Area Boundary

Each OSPF interface belongs to a single area and all MTs sharing that link need to belong to the same area. Therefore the area boundaries for all MTs are the same but each MT's attachment to the area is independent.

3.2 Adjacency for MTs

Each interface can be configured to belong to a set of topologies. A single adjacency will be formed with neighbors on the interface even if the interface is configured to participate in multiple topologies. Furthermore, adjacency formation will be independent of the topologies configured for the interface or neighbors on that interface.

3.3 Sending OSPF control packets

Sending OSPF control packets is unchanged from RFC2328. For OSPF control packets sent to the remote end of a virtual link, the transit area path MUST be composed solely of links in the default topology and the OSPF control packets MUST be forwarded using the default topology.

3.4 Advertising MT Adjacencies and the Corresponding IP Prefixes

We will reuse the TOS metric field in order to advertise a topology and prefixes belonging to that topology. The TOS field is redefined as MT-ID in the payload of Router-LSAs, Summary-LSAs, NSSA-LSAs, and AS-External-LSAs (see Appendix A).

MT-ID metrics in LSAs SHOULD be in ascending order of MT-ID. If an MT-ID exists in an LSA or router link multiple times, the metric in the first MT-ID instance MUST be used.

3.4.1 Advertising MT Adjacencies and the Corresponding IP Prefixes

When a router establishes a FULL adjacency over a link that belongs to a set of MTs, it will advertise the corresponding cost for each MT-ID.

By default, all links are included in default topology and all advertised prefixes belonging to the default topology will use the TOS0 metric the same as in standard OSPF [OSPF].

Each MT has its own MT-ID metric field. When a link is not part of a

given MT, the corresponding MT-ID metric is excluded from the LSA.

The Network-LSA does not contain any MT information since the DR is shared by all MTs. Hence, there is no change to the Network-LSA.

3.4.2 Inter-Area and External Routing

In Summary-LSAs, NSSA-LSAs, and AS-External-LSAs, the TOS metric fields are defined as MT-ID metric fields and are used in order to advertise prefix and router reachability in the corresponding topology.

When a router originates a Summary-LSA, NSSA-LSA, or AS-External-LSA that belongs to a set of MTs, it will include the corresponding cost for each MT-ID. By default, the router participates in the default topology and uses the TOS0 metric for the default topology the same as in standard OSPF [OSPF].

Setting the P-bit in NSSA-LSAs is topology independent and pertains to all MT-ID advertised in the body of the LSA.

3.5 Flushing MT Information

When a certain link or prefix that existed or was reachable in a certain topology is no longer part of that topology or is unreachable in that topology, a new version of the LSA must be originated excluding metric information representing the link or prefix in that topology.

The MT metric in the Router-LSA can also be set to the maximum possible metric to enable the router to become a stub in a certain topology [STUB].

3.6 MT SPF Computation

By considering MT-ID metrics in the LSAs, OSPF will be able to compute multiple topologies and find paths to IP prefixes for each MT independently. A separate SPF will be computed for each MT-ID to find independent paths to IP prefixes. Each nexthop computed during the MT SPF MUST belong to the same MT.

Network-LSAs are used by all topologies during the SPF computation. During the SPF for a given MT-ID, only the links and metrics for that MT-ID will be considered. Entries in the Router Routing table will be MT-ID specific.

During the SPF computation for the default topology only the TOS0 metric is considered during the SPF computation.

3.7 MT-ID Values

Since AS-External-LSAs use the high order bit in the MT-ID field (E bit) for the external metric-type, only MT-IDs in the range [0-127] are valid. The following MT-ID values are reserved:

0 - Reserved for advertising the metric associated with the default topology (see Section 4.2)

1 - Reserved for advertising the metric associated with the default multicast topology

MT-IDs [128-255] SHOULD be ignored.

3.8 Forwarding in MT

It's outside of the scope of this document to specify how the information in various topology specific forwarding structures are used during packet forwarding or how incoming packets are associated with the corresponding topology. For correct operation, both forwarding behavior and methods of associating incoming packets to a corresponding topology must be consistently applied in the network.

4. Default Topology Link Exclusion Functional Specifications

The multi-topologies imply that all the routers participate in the default topology. However, it can be useful to exclude some links from the default topology and reserve them for some specific classes of traffic.

The multi-topologies extension for default topology link or prefix exclusion is described in the following subsections.

4.1 Exclusion of Links in the Default Topology

OSPF does not have the notion of an unreachable link. All links can have a maximum metric of 0xFFFF advertised in the Router-LSA. The link exclusion capability requires routers to ignore TOS0 metrics in Router-LSAs in the default topology and to alternately use the MT-ID#0 metric to advertise the metric associated with the default topology. Hence, all routers within an area MUST agree on how the metric for default topology will be advertised.

The unused T-bit is defined as the MT-bit in the option field in order to assure that a multi-topology link-excluding capable router will only form an adjacency with another similarly configured router.

```
+---+---+---+---+---+---+---+---+
|DN |O  |DC |EA |NP |MC |E  |MT |
+---+---+---+---+---+---+---+---+
```

MT-bit: This bit MUST be set in the Hello packet only if DefaultExclusionCapability is enabled (see Section 4.2)

4.2 New Area Data Structure Parameter

We define a new parameter in the Area Data Structure:

DefaultExclusionCapability
This configurable parameter ensures that all routers in an area have this capability enabled before the default topology can be disabled on a router link in the area without causing backward compatibility problems.

When an area data structure is created the DefaultExclusionCapability is disabled by default.

If DefaultExclusionCapability is disabled:

- The MT-bit MUST be cleared in Hello packets.

- If a link participates in a non-default topology, it is automatically included in the default topology to support backward compatibility between MT and non-MT routers. This is accomplished through advertisement via the TOS0 metric field the same as in standard OSPF [OSPF].

If DefaultExclusionCapability is enabled:

- The MT-bit MUST be set in Hello packets

- The router will only accept a Hello if the MT-bit is set (see Section 4.3)

When DefaultExclusionCapability is set to enabled a router is said to be operating in DefaultExclusionCapability mode.

4.3 Adjacency Formation with Link Exclusion Capability

In order to have a smooth transition from a non-MT area to an MT-area, an MT router with DefaultExclusionCapability disabled will form adjacencies with non-MT routers and will include all links as part of default topology.

A link may cease participating in default topology if DefaultExclusionCapability is set to enabled. In this state, a router will only form adjacency with routers that set the MT-bit in their Hello packets. This will ensure that all routers have DefaultExclusionCapability enabled before the default topology can be disabled on a link.

Receiving OSPF Hello packets as defined in section 10.5 of [OSPF] is modified as follows:

- If the DefaultExclusionCapability of the Area Data structure is set to enabled, the Hello packets are discarded if the the received Hello packet does not have the MT-bit in the hello options set.

4.4 OSPF Control Packets Transmission Over Excluded Links

If DefaultExclusionCapability is enabled, the default topology can be disabled on an interface. Disabling the default topology on an interface does not impact the installation of connected routes for the interface in the default topology. It only affects what a router advertises in its Router-LSA.

This allows OSPF control packets to be sent and received over an interface even if the default topology is disabled on the interface.

4.5 OSPF LSA Advertisement and SPF Computation for Excluded Links

When DefaultExclusionCapability is enabled and the link does not participate in the default topology, the MT-ID#0 metric is not advertised. The link's TOS0 metric is ignored during the default topology SPF computation.

When DefaultExclusionCapability is enabled and a link participates in the default topology, MT-ID#0 metric is used to advertise the metric associated with the default topology. The link's TOS0 metric is ignored during the default topology SPF computation.

Independent of the DefaultExclusionCapability setting, the TOS0 metric is used for Summary-LSAs, NSSA-LSAs, and AS-External-LSAs.

- o If the prefix or router does not exist in the default topology, the TOS0 metric is set to infinity (0xFFFFFF).

- o If the prefix or router exists in default the topology, the TOS0 metric is used to advertise the metric in the default topology.

During the summary and external prefix calculation for the default topology the TOS0 metric is used for Summary-LSAs, NSSA-LSAs, and AS-External-LSAs.

5. Interoperability between MT Capable and Non-MT Capable Routers

The default metric field is mandatory in all LSAs (even when metric value is 0). Even when a link or prefix does not exist in the default topology, a non-MT router can consider the zero value in the metric field as a valid metric and consider the link or prefix as part of the default topology.

In order to prevent the above problem, an MT capable router will include all links as part of the default topology. If links need to be removed from the default topology, an MT capable router MUST be configured in DefaultExclusionCapability mode. In this mode, routers will assure that all other routers in the area are in the DefaultExclusionCapability mode before considering the MT-ID#0 metric in the SPF calculation. Only then can the TOS0 metric field in Router LSAs be safely ignored during the default topology SPF computation.

Note that for any prefix or router to become reachable in a certain topology, a contiguous path inside that topology must exist between the calculating router and the destination prefix or router.

6. Migration from non-MT-Area to MT-area

Introducing MT-OSPF into a network can be done gradually to allow MT routers and non-MT routers to participate in the default topology while MT routers participate in other topologies.

If there is a requirement to exclude some links from the default topology in an area, all routers in the area MUST be in DefaultExclusionCapability mode. In this section we describe the migration steps to consider while transitioning from a non-MT network to an MT network.

Consider a network with a backbone area and a set of non-backbone areas functioning in standard OSPF mode. We would like to migrate to an MT network either partially or completely.

1. As required, part of an area is upgrade to be MT capable. The MT routers will interact with non-MT routers in the default topology and participate in other topologies as required.

2. If a new non-backbone area is created for MT routers, it may be configured in DefaultExclusionCapability mode since there is no interaction required with non-MT routers. In this mode, the default topology can be excluded on links as required.

3. If there is more than one non-backbone areas where MT is being used, it is desirable that the backbone area first be upgraded to be MT capable so that inter-area routing is assured for MT destinations in different areas.

4. Gradually the whole network can be made MT capable.

Note that inter-area routing for the MT-area still depends on the backbone area. Therefore, if different areas configured for a given topology need to communicate, the backbone area also needs to be configured for this topology.

7. Security Considerations

This document does not raise any security issues that are not already covered in [OSPF].

8. IANA Considerations

The T-bit as defined in [RFC1583] for a router's TOS capability is redefined as the MT-bit in this document. Similarly, the TOS field for Router-LSAs, Summary-LSAs, NSSA-LSAs, and AS-External LSAs as defined in [OSPF] is redefined as MT-ID in this document.

9. References

9.1 Normative References

[NSSA] Murphy, P., "The OSPF Not-So-Stubby Area (NSSA) Option", RFC 3101, January 2003.

[OSPF] Moy, J., "OSPF Version 2", RFC 2328, April 1998.

[RFC1583] Moy, J., "OSPF Version 2", RFC 1583, March 1994.

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

9.2 Informative References

[M-ISIS] Przygienda, T., Shen, N., and N. Sheth, "M-ISIS: Multi Topology (MT) Routing in IS-IS", draft-ietf-isis-wg-multi-topology-07.txt (work in progress).

[STUB] Retana, A., Nguyen, L., White, R., Zinin, A., and D. McPherson, "OSPF Stub Router Advertisement", RFC 3137, June 2001.

Authors' Addresses

Peter Psenak
Cisco Systems
Parc Pegasus, De Kleetlaan 6A
1831 Diegem
Belgium

Email: ppsenak@cisco.com

Sina Mirtorabi
Cisco Systems
225 West Tasman Drive
San Jose, CA 95134
USA

Email: sina@cisco.com

Abhay Roy
Cisco Systems
225 West Tasman Drive
San Jose, CA 95134
USA

Email: akr@cisco.com

Liem Nguyen
Cisco Systems
7025 Kit Creek Road
Research Triangle Park, NC 27709
USA

Email: lhnguyen@cisco.com

Padma Pillay-Esnault
Cisco Systems
225 West Tasman Drive
San Jose, CA 95134
USA

Email: ppe@cisco.com

Appendix A. Acknowledgments

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Appendix B. OSPF data formats

LSA content defined in [OSPF] is modified to introduce the MT-ID.

B.1 Router-LSAs

Router-LSAs are the Type 1 LSAs. Each router in an area originates a router-LSA. The LSA describes the state and cost of the router's links (i.e., interfaces) to the area. All of the router's links to the area must be described in a single router-LSA. For details concerning the construction of router-LSAs, see Section 12.4.1 [OSPF].

```
     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
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     |            LS age             |     Options   |       1       |
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     |                        Link State ID                          |
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     |                     Advertising Router                        |
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     |                     LS sequence number                        |
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     |         LS checksum           |             length            |
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     |*|*|*|N|W|V|E|B|        0      |            # links            |
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     |                          Link ID                              |
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     |                         Link Data                             |
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     |     Type      |     # MT-ID   |            metric             |
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     |     MT-ID     |       0       |          MT-ID  metric        |
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     |                              ...                              |
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     |     MT-ID     |       0       |          MT-ID  metric        |
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     |                          Link ID                              |
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     |                         Link Data                             |
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     |                              ...                              |
```

B.2 Network-LSAs

Network-LSAs are the Type 2 LSAs. A network-LSA is originated for each broadcast and NBMA network in the area which supports two or more routers. The network-LSA is originated by the network's Designated Router. The LSA describes all routers attached to the network, including the Designated Router itself. The LSA's Link State ID field lists the IP interface address of the Designated Router.

The distance from the network to all attached routers is zero. This is why metric fields need not be specified in the network-LSA. For details concerning the construction of network-LSAs, see Section 12.4.2 [OSPF].

```
 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|            LS age             |      Options  |      2        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                        Link State ID                          |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                     Advertising Router                        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                     LS sequence number                        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|         LS checksum           |             length            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                         Network Mask                          |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                        Attached Router                        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                              ...                              |
```

Note that network LSA does not contain any MT-ID fields as the cost of the network to the attached routers is 0 and DR is shared by all topologies.

B.3 Summary-LSAs

Summary-LSAs are the Type 3 and 4 LSAs. These LSAs are originated by area border routers. Summary-LSAs describe inter-area destinations. For details concerning the construction of summary- LSAs, see Section 12.4.3 [OSPF].

Type 3 summary-LSAs are used when the destination is an IP network. In this case the LSA's Link State ID field is an IP network number

(if necessary, the Link State ID can also have one or more of the network's "host" bits set; see Appendix E [OSPF] for details). When the destination is an AS boundary router, a Type 4 summary-LSA is used, and the Link State ID field is the AS boundary router's OSPF Router ID. (To see why it is necessary to advertise the location of each ASBR, consult Section 16.4 of [OSPF]). Other than the difference in the Link State ID field, the format of Type 3 and 4 summary-LSAs is identical.

```
 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|            LS age             |     Options   |    3 or 4     |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                        Link State ID                          |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                     Advertising Router                        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                     LS sequence number                        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|         LS checksum           |             length            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                         Network Mask                          |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|      0        |                  metric                       |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|     MT-ID     |                MT-ID  metric                  |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                              ...                              |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|     MT-ID     |                MT-ID  metric                  |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

B.4 AS-External-LSAs

AS-external-LSAs are the Type 5 LSAs. These LSAs are originated by AS boundary routers, and describe destinations external to the AS. For details concerning the construction of AS-external-LSAs, see Section 12.4.3 [OSPF].

AS-external-LSAs usually describe a particular external destination. For these LSAs the Link State ID field specifies an IP network number (if necessary, the Link State ID can also have one or more of the network's "host" bits set; see Appendix E [OSPF] for details). AS-external-LSAs are also used to describe a default route. Default routes are used when no specific route exists to the destination.

When describing a default route, the Link State ID is always set to DefaultDestination (0.0.0.0) and the Network Mask is set to 0.0.0.0.

```
 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|            LS age             |     Options   |      5        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                        Link State ID                          |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                     Advertising Router                        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                     LS sequence number                        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|         LS checksum           |             length            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                         Network Mask                          |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|E|     0       |                  metric                       |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                      Forwarding address                       |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                      External Route Tag                       |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|E|    MT-ID    |              MT-ID  metric                    |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                      Forwarding address                       |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                      External Route Tag                       |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                              ...                              |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|E|    MT-ID    |              MT-ID  metric                    |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                      Forwarding address                       |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                      External Route Tag                       |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

B.5 NSSA-LSAs

NSSA-LSAs are the Type 7 LSAs. These LSAs are originated by AS boundary routers local to an NSSA, and describe destinations external to the AS. The changes to NSSA-LSAs are identical to those for External-LSAs (Appendix A.4.5). For details concerning the construction of NSSA-LSAs see Section 2.4 [NSSA].

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