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# The OSPF Opaque LSA Option

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## Status of this Memo



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## Abstract

This document defines enhancements to the OSPF protocol to support a new class of link-state advertisements (LSA) called Opaque LSAs. Opaque LSAs provide a generalized mechanism to allow for the future extensibility of OSPF. Opaque LSAs consist of a standard LSA header followed by application-specific information. The information field may be used directly by OSPF or by other applications. Standard OSPF link-state database flooding mechanisms are used to distribute Opaque

LSAs to all or some limited portion of the OSPF topology.

This document replaces RFC 2370 and adds to it a mechanism to enable





an OSPF router to validate AS-scope opaque LSAs originated outside of the router's OSPF area.

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## 1. Conventions used in this document

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].

## 2. Introduction

Over the last several years the OSPF routing protocol [OSPF] has been widely deployed throughout the Internet. As a result of this deployment and the evolution of networking technology, OSPF has been extended to support many options; this evolution will obviously continue.

This document defines enhancements to the OSPF protocol to support a new class of link-state advertisements (LSA) called Opaque LSAs. Opaque LSAs provide a generalized mechanism to allow for the future extensibility of OSPF. The information contained in Opaque LSAs may be used directly by OSPF or indirectly by some application wishing to distribute information throughout the OSPF domain. The exact use of Opaque LSAs is beyond the scope of this document.

Opaque LSAs consist of a standard LSA header followed by a 32-bit aligned application-specific information field. Like any other LSA, the Opaque LSA uses the link-state database distribution mechanism for flooding this information throughout the topology. The link-state type field of the Opaque LSA identifies the LSA's range of topological distribution. This range is referred to as the Flooding Scope.

It is envisioned that an implementation of the Opaque option provides an application interface for 1) encapsulating application-specific

information in a specific Opaque type, 2) sending and receiving application-specific information, and 3) if required, informing the application of the change in validity of previously received information when topological changes are detected.

## 2.1. Organization Of This Document

This document first defines the three types of Opaque LSAs followed by a description of OSPF packet processing. The packet processing sections include modifications to the flooding procedure and to the neighbor state machine. Appendix A then gives the packet formats.





## 2.2. Acknowledgments

We would like to thank Acee Lindem for his detailed review and useful feedback. The handling of AS-scope opaque LSAs described in this document is taken from draft-bryskin-ospf-lsa-type11-validation-00.txt.

# 3. The Opaque LSA

Opaque LSAs are types 9, 10, and 11 link-state advertisements. Opaque LSAs consist of a standard LSA header followed by a 32-bit aligned application-specific information field. Standard link-state database flooding mechanisms are used for distribution of Opaque LSAs. The range of topological distribution (i.e., the flooding scope) of an Opaque LSA is identified by its link-state type. This section documents the flooding of Opaque LSAs.

The flooding scope associated with each Opaque link-state type is defined as follows.

- Link-state type-9 denotes a link-local scope. Type-9 Opaque LSAs are not flooded beyond the local (sub)network.

- Link-state type-10 denotes an area-local scope. Type-10 Opaque LSAs are not flooded beyond the borders of their associated area.

- Link-state type-11 denotes that the LSA is flooded throughout the Autonomous System (AS). The flooding scope of type-11 LSAs are equivalent to the flooding scope of AS-external (type-5) LSAs. Specifically, type-11 Opaque LSAs are 1) flooded throughout all transit areas, 2) not flooded into stub areas or Not-So-Stubby Areas (NSSAs), see [NSSA], from the backbone and 3) not originated by routers into their connected stub areas or NSSAs. As with type-5 LSAs, if a type-11 Opaque LSA is received in a stub area or NSSA from a neighboring router within the stub area or NSSA the LSA is rejected.

The link-state ID of the Opaque LSA is divided into an Opaque type field (the first 8 bits) and a type-specific ID (the remaining 24 bits). The packet format of the Opaque LSA is given in Appendix A. Section 7 describes Opaque type allocation and assignment.

The responsibility for proper handling of the Opaque LSA's flooding scope is placed on both the sender and receiver of the LSA. The receiver must always store a valid received Opaque LSA in its link-state database. The receiver must not accept Opaque LSAs that violate the flooding scope (e.g., a type-11 (domain-wide) Opaque LSA





is not accepted in a stub area or NSSA). The flooding scope effects both the synchronization of the link-state database and the flooding procedure.

The following describes the modifications to these procedures that are necessary to insure conformance to the Opaque LSA's Scoping Rules.

## 3.1. Flooding Opaque LSAs

The flooding of Opaque LSAs MUST follow the rules of Flooding Scope as specified in this section. Section 13 of [OSPF] describes the OSPF flooding procedure. Those procedures MUST be followed as defined except where modified in this section. The following describes the Opaque LSA's type-specific flooding restrictions.

- If the Opaque LSA is type-9 (the flooding scope is link-local) and the interface that the LSA was received on is not the same

as the target interface (e.g., the interface associated with a particular target neighbor), the Opaque LSA MUST be discarded and not acknowledged. An implementation SHOULD keep track of the IP interface associated with each Opaque LSA having a link-local flooding scope.

- If the Opaque LSA is type-10 (the flooding scope is area-local) and the area associated with the Opaque LSA (as identified during origination or from a received LSA's associated OSPF packet header) is not the same as the area associated with the target interface, the Opaque LSA MUST be discarded and not acknowledged. An implementation SHOULD keep track of the OSPF area associated with each Opaque LSA having an area-local flooding scope.

- If the Opaque LSA is type-11 (the LSA is flooded throughout the AS) and the target interface is associated with a stub area or NSSA, the Opaque LSA MUST NOT be flooded out the interface. A type-11 Opaque LSA that is received on an interface associated with a stub area or NSSA MUST be discarded and not acknowledged (the neighboring router has flooded the LSA in error).

When opaque-capable routers and non-opaque-capable OSPF routers are mixed together in a routing domain, the Opaque LSAs are typically not flooded to the non-opaque-capable routers. As a general design principle, optional OSPF advertisements are only flooded to those routers that understand them.

An opaque-capable router learns of its neighbor's opaque capability





at the beginning of the "Database Exchange Process" (see Section 10.6 of [OSPF], receiving Database Description packets from a neighbor in state ExStart). A neighbor is opaque-capable if and only if it sets the O-bit in the Options field of its Database Description packets; the O-bit SHOULD NOT be set and MUST be ignored when received in packets other than Database Description packets. Using the O-bit in OSPF packets other than Database Description packets will result in interoperability issues. The setting of the O-bit is a "SHOULD NOT" rather than a "MUST NOT" to remain compatible with earlier specifications.

In the next step of the Database Exchange process, Opaque LSAs are

included in the Database summary list that is sent to the neighbor (see Sections 3.2 below and 10.3 of [OSPF]) when the neighbor is opaque capable.

When flooding Opaque-LSAs to adjacent neighbors, an opaque-capable router looks at the neighbor's opaque capability. Opaque LSAs are only flooded to opaque-capable neighbors. To be more precise, in Section 13.3 of [OSPF], Opaque LSAs MUST be placed on the link-state retransmission lists of opaque-capable neighbors and MUST NOT be placed on the link-state retransmission lists of non-opaque-capable neighbors. However, when sending Link State Update packets as multicasts, a non-opaque-capable neighbor may (inadvertently) receive Opaque LSAs. The non-opaque-capable router will then simply discard the LSA (see Section 13 of [OSPF], receiving LSAs having unknown LS types).

Information contained in received opaque LSAs SHOULD only be used when the router originating the LSA is reachable. As mentioned in [OSPFv3], reachability validation MAY be done less frequently than every SPF calculation. Additionally, routers processing received opaque LSAs MAY choose to give priority to processing base OSPF LSA types over opaque LSA types.

## 3.2. Modifications To The Neighbor State Machine

The state machine as it exists in section 10.3 of [OSPF] remains unchanged except for the action associated with State: ExStart, Event: NegotiationDone which is where the Database summary list is built. To incorporate the Opaque LSA in OSPF this action is changed to the following.

State(s): ExStart

Event: NegotiationDone





New state: Exchange

Action: The router MUST list the contents of its entire area link-state database in the neighbor Database summary list. The area link-state database consists of the

Router LSAs, Network LSAs, Summary LSAs, type-9 opaque LSAs, and type-10 opaque LSAs contained in the area structure, along with AS External and type-11 Opaque LSAs contained in the global structure. AS External and type-11 Opaque LSAs MUST be omitted from a virtual neighbor's Database summary list. AS External LSAs and type-11 Opaque LSAs MUST be omitted from the Database summary list if the area has been configured as a stub area or NSSA (see Section 3.6 of [OSPF]).

Type-9 Opaque LSAs MUST be omitted from the Database summary list if the interface associated with the neighbor is not the interface associated with the Opaque LSA (as noted upon reception).

Any advertisement whose age is equal to MaxAge MUST be omitted from the Database summary list. It MUST instead be added to the neighbor's link-state retransmission list. A summary of the Database summary list will be sent to the neighbor in Database Description packets. Only one Database Description Packet is allowed to be outstanding at any one time. For more detail on the sending and receiving of Database Description packets, see Sections 10.6 and 10.8 of [OSPF].

## 4. Protocol Data Structures

The Opaque option is described herein in terms of its operation on various protocol data structures. These data structures are included for explanatory uses only. They are not intended to constrain an implementation. In addition to the data structures listed below, this specification references the various data structures (e.g., OSPF neighbors) defined in [OSPF].

In an OSPF router, the following item is added to the list of global OSPF data structures described in Section 5 of [OSPF]:

- Opaque capability. Indicates whether the router is running the Opaque option (i.e., capable of storing Opaque LSAs). Such a router will continue to inter-operate with non-opaque-capable OSPF routers.

### 4.1. Additions To The OSPF Neighbor Structure

The OSPF neighbor structure is defined in Section 10 of [OSPF]. In an opaque-capable router, the following items are added to the OSPF neighbor structure:

- Neighbor Options. This field was already defined in the OSPF specification. However, in opaque-capable routers there is a new option which indicates the neighbor's Opaque capability. This new option is learned in the Database Exchange process through reception of the neighbor's Database Description packets and determines whether Opaque LSAs are flooded to the neighbor. For a more detailed explanation of the flooding of the Opaque LSA see section 3 of this document.

## 5. Inter-Area Considerations

As defined above, link-state type-11 opaque LSAs are flooded throughout the Autonomous System (AS). One issue related to such AS scoped Opaque LSAs is that there must be a way for OSPF routers in remote areas to check availability of the LSA originator. Specifically, if an OSPF router originates a type-11 LSA and, after that, goes out of service, OSPF routers located outside of the originator's OSPF area have no way of detecting this fact and may use the stale information for a considerable period of time (up to 60 minutes). This could prove to be suboptimal for some applications and may result in others not functioning.

Type-9 opaque LSAs and type-10 opaque LSAs do not have this problem as a receiving router can detect if the advertising router is reachable within the LSA's respective flooding scope. In the case of type-9 LSAs, the originating router must be an OSPF neighbor in Exchange state or greater. In the case of type-10 Opaque LSAs, the intra-area SPF calculation will determine the advertising router's reachability.

There is a parallel issue in OSPF for the AS scoped AS-external-LSAs (type-5 LSAs). OSPF addresses this by using AS border information advertised in AS boundary router (ASBR) summary-LSAs (type-4 LSAs), see [OSPF] Section 16.4. This same mechanism is reused by this document for type-11 opaque LSAs.

To enable OSPF routers in remote areas to check availability of the originator of link-state type-11 opaque LSAs, the originators advertise themselves as ASBRs. This will enable routers to track the reachability of the LSA originator either directly via the SPF calculation (for routers in the same area) or indirectly via type-4

LSAs originated by ABRs (for routers in other areas). It is important to note that per [OSPF] this solution does not apply to OSPF stub areas or NSSAs as AS scoped opaque LSAs are not flooded into these area types.

The procedures related to inter-area opaque LSAs are as follows:

(1) An OSPF router that is configured to originate AS-scope opaque LSAs will advertise itself as an ASBR and MUST follow the requirements related to setting of the Options field E-bit in OSPF LSA headers as specified in [OSPF].

(2) When processing a received type-11 Opaque LSA, the router MUST look up the routing table entries (potentially one per attached area) for the AS boundary router (ASBR) that originated the LSA. If no entries exist for router ASBR (i.e., the ASBR is unreachable), the router MUST do nothing with this LSA. It also MUST discontinue using all Opaque LSAs injected into the network by the same originator whenever it is detected that the originator is unreachable.

## 6. Management Considerations

The updated OSPF MIB, [RFC4750], provides explicit support for opaque LSAs and SHOULD be used to support implementations of this document. See Section 12.3 of [RFC4750] for details. In addition to that section, implementations supporting [RFC4750] will also include opaque LSAs in all appropriate generic LSA objects, e.g., ospfOriginateNewLsas, and ospfLsdbTable.

## 7. Backward Compatibility

The solution proposed in this document introduces no interoperability issues. In the case that a non-opaque-capable neighbor receives Opaque LSAs, per [OSPF], the non-opaque-capable router will simply discard the LSA.

Note that OSPF routers that implement [RFC2370] will continue using stale type-11 LSAs even when the LSA originator implements the Inter-area procedures described in Section 6 of this document.

## 8. Security Considerations

There are two types of issues that need be addressed when looking at protecting routing protocols from misconfigurations and malicious attacks. The first is authentication and certification of routing protocol information. The second is denial of service attacks resulting from repetitive origination of the same router advertisement or origination of a large number of distinct advertisements resulting in database overflow. Note that both of these concerns exist independently of a router's support for the Opaque option.

To address the authentication concerns, OSPF protocol exchanges are authenticated. OSPF supports multiple types of authentication; the type of authentication in use can be configured on a per network segment basis. One of OSPF's authentication types, namely the Cryptographic authentication option, is believed to be secure against passive attacks and provide significant protection against active attacks. When using the Cryptographic authentication option, each router appends a "message digest" to its transmitted OSPF packets. Receivers then use the shared secret key and received digest to verify that each received OSPF packet is authentic.

The quality of the security provided by the Cryptographic authentication option depends completely on the strength of the message digest algorithm (MD5 is currently the only message digest algorithm specified), the strength of the key being used, and the correct implementation of the security mechanism in all communicating OSPF implementations. It also requires that all parties maintain the secrecy of the shared secret key. None of the standard OSPF authentication types provide confidentiality. Nor do they protect against traffic analysis. For more information on the standard OSPF security mechanisms, see Sections 8.1, 8.2, and Appendix D of [OSPF].

Repetitive origination of advertisements is addressed by OSPF by

mandating a limit on the frequency that new instances of any particular LSA can be originated and accepted during the flooding procedure. The frequency at which new LSA instances may be originated is set equal to once every MinLSInterval seconds, whose value is 5 seconds (see Section 12.4 of [OSPF]). The frequency at which new LSA instances are accepted during flooding is once every MinLSArrival seconds, whose value is set to 1 (see Section 13, Appendix B and G.5 of [OSPF]).

Proper operation of the OSPF protocol requires that all OSPF routers maintain an identical copy of the OSPF link-state database. However, when the size of the link-state database becomes very large, some routers may be unable to keep the entire database due to resource





shortages; we term this "database overflow". When database overflow is anticipated, the routers with limited resources can be accommodated by configuring OSPF stub areas and NSSAs. [OVERFLOW] details a way of gracefully handling unanticipated database overflows.

In the case of type-11 Opaque LSAs, this document reuses an ASBR tracking mechanism that is already employed in basic OSPF for type-5 LSAs. Therefore, applying it to type-11 Opaque LSAs does not create any threats that are not already known for type-5 LSAs.

## 9. IANA Considerations

This document updates the requirements for the OSPF Opaque LSA type registry, see http://www.iana.org/assignments/ospf-opaque-types. Three changes are requested. The first is for references to [RFC2370] to be replaced with references to this document. The second change is for the Opaque type values in the range of 128-255 to be reserved for "Private Use" as defined in [RFC2434]. The final change is for the reference for registry value 1, Traffic Engineering LSA, to be updated to [RFC3630].

With these changes integrated, the registry should read:

> Open Shortest Path First (OSPF) Opaque Link-State Advertisements (LSA) Option Types

Registries included below:
- Opaque Link-State Advertisements (LSA) Option Types

Registry Name: Opaque Link-State Advertisements (LSA) Option Types
Reference: [This document]

| Range | Registration Procedures | Notes |
|---|---|---|
| 0-127 | IETF Consensus | |
| 128-255 | Private Use | |

Registry:

| Value | Opaque Type | Reference |
|---|---|---|
| 1 | Traffic Engineering LSA | [RFC3630] |
| 2 | Sycamore Optical Topology Descriptions | [Moy] |
| 3 | grace-LSA | [RFC3623] |
| 4 | Router Information (RI) | [RFC4970] |
| 5-127 | Unassigned | |
| 128-255 | Private Use | |





## 10. References

### 10.1. Normative References

[DEMD] Moy, J., "Extending OSPF to Support Demand Circuits", RFC 1793, April 1995.

[OSPF] Moy, J., "OSPF Version 2", STD 54, RFC 2328, April 1998.

[RFC2119] Bradner, S., "Key words for use in RFCs to indicate requirements levels", RFC 2119, March 1997.

[RFC2434] Narten, T., Alvestrand, H., "Guidelines for Writing an IANA Considerations Section in RFCs ", RFC 2434, October 1998.

[RFC4750] Joyal, D., et al., "OSPF Version 2 Management Information Base", RFC 4750, November 2006.

### 10.2. Informative References

[MOSPF] Moy, J., "Multicast Extensions to OSPF", RFC 1584, March 1994.

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

[OSPF-MT] Psenak, P., et al., "Multi-Topology (MT) Routing in OSPF", draft-ietf-ospf-mt-, January 2007.

[OSPFv3] Coltun, R., et al. "OSPF for IPv6", draft-ietf-ospf-ospfv3-update-21.txt, April 2008.

[OVERFLOW] Moy, J., "OSPF Database Overflow", RFC 1765, March 1995.

[RFC2370] Coltun, R., "The OSPF Opaque LSA Option", RFC 2370, July 1998.

[RFC3630] Katz, D., Kompella, K., Yeund, D., "Traffic Engineering (TE) Extensions to OSPF Version 2", RFC 3630, September 2003.

[RFC4576] Rosen, E., et al., "Using a Link State Advertisement (LSA) Options Bit to Prevent Looping in BGP/MPLS IP Virtual Private Networks (VPNs)", RFC 4576, June 2006.





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## 12. Appendix A: OSPF Data formats

This appendix describes the format of the Options Field followed by the packet format of the Opaque LSA.

### 12.1. The Options Field

The OSPF Options field is present in OSPF Hello packets, Database Description packets and all link-state advertisements. The Options field enables OSPF routers to support (or not support) optional capabilities, and to communicate their capability level to other OSPF routers. Through this mechanism routers of differing capabilities can be mixed within an OSPF routing domain.

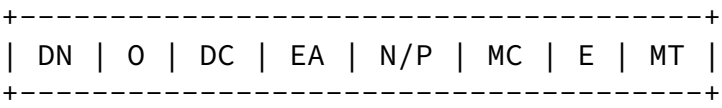
When used in Hello packets, the Options field allows a router to reject a neighbor because of a capability mismatch. Alternatively, when capabilities are exchanged in Database Description packets a router can choose not to flood certain link-state advertisements to a neighbor because of its reduced functionality. Lastly, listing capabilities in link-state advertisements allows routers to forward traffic around reduced functionality routers by excluding them from parts of the routing table calculation.

All eight bits of the OSPF Options field have been assigned, although only the O-bit is described completely by this document. Each bit is





described briefly below. Routers SHOULD reset (i.e., clear) unrecognized bits in the Options field when sending Hello packets or Database Description packets and when originating link-state advertisements. Conversely, routers encountering unrecognized Option bits in received Hello Packets, Database Description packets or link-state advertisements SHOULD ignore the capability and process the packet/advertisement normally.




The Options Field

MT-bit
: This bit describes the router's multi-topology link-excluding capability, as described in [OSPF-MT].

E-bit
: This bit describes the way AS-external-LSAs are flooded, as described in Sections 3.6, 9.5, 10.8 and 12.1.2 of [OSPF].

MC-bit
: This bit describes whether IP multicast datagrams are forwarded according to the specifications in [MOSPF].

N/P-bit
: This bit describes the handling of Type-7 LSAs, as specified in [NSSA].

DC-bit
: This bit describes the router's handling of demand circuits, as specified in [DEMD].

EA-bit
: This bit describes the router's willingness to receive and forward External-Attributes-LSAs. While defined, the documents specifying this bit have all expired. The use of this bit may be deprecated in the future.

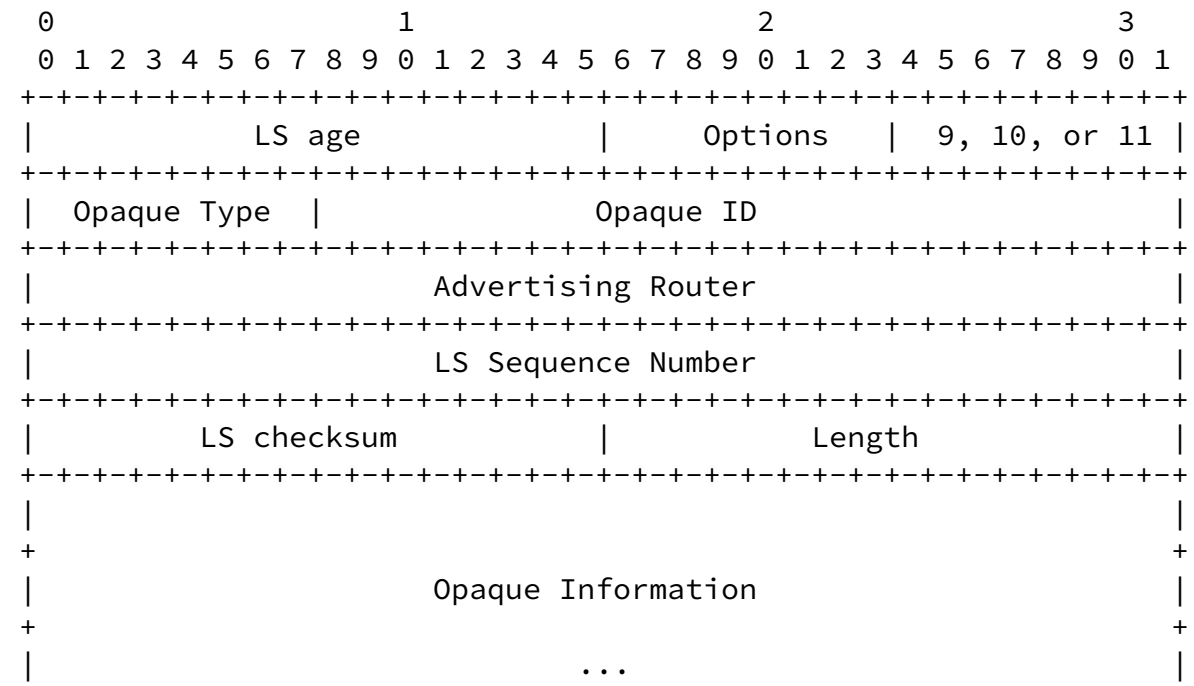
O-bit
: This bit describes the router's willingness to receive and forward Opaque-LSAs as specified in this document.

DN-bit
: This bit is used to prevent looping in BGP/MPLS IP VPNs, as specified in [RFC4576].

## 12.2. The Opaque LSA

Opaque LSAs are Type 9, 10, and 11 link-state advertisements. These advertisements MAY be used directly by OSPF or indirectly by some application wishing to distribute information throughout the OSPF domain. The function of the Opaque LSA option is to provide for future OSPF extensibility.

Opaque LSAs contain some number of octets (of application-specific data) padded to 32-bit alignment. Like any other LSA, the Opaque LSA uses the link-state database distribution mechanism for flooding this information throughout the topology. However, the Opaque LSA has a flooding scope associated with it so that the scope of flooding may be link-local (type-9), area-local (type-10) or the entire OSPF routing domain (type-11). Section 3 of this document describes the flooding procedures for the Opaque LSA.




Link-State Type

The link-state type of the Opaque LSA identifies the LSA's range of topological distribution. This range is referred to as the Flooding Scope. The following explains the flooding scope of each of the link-state types.

- A value of 9 denotes a link-local scope. Opaque LSAs with a link-local scope MUST NOT be flooded beyond the local (sub)network.

- A value of 10 denotes an area-local scope. Opaque LSAs with a

area-local scope MUST NOT be flooded beyond their area of origin.

- A value of 11 denotes that the LSA is flooded throughout the Autonomous System (e.g., has the same scope as type-5 LSAs). Opaque LSAs with AS-wide scope MUST NOT be flooded into stub areas or NSSAs.

Syntax Of The Opaque LSA's Link-State ID

The link-state ID of the Opaque LSA is divided into an Opaque Type field (the first 8 bits) and an Opaque ID (the remaining 24 bits). See section 7 of this document for a description of Opaque type allocation and assignment.

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