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OSPFv3 Auto-Configuration
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Abstract

OSPFv3 is a candidate for deployments in environments where auto-configuration is a requirement. One such environment is the IPv6 home network where users expect to simply plug in a router and have it automatically use OSPFv3 for intra-domain routing. This document describes the necessary mechanisms for OSPFv3 to be self-configuring.

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1. Introduction

OSPFv3 [OSPFV3] is a candidate for deployments in environments where auto-configuration is a requirement. Its operation is largely unchanged from the base OSPFv3 protocol specification [OSPFV3].

The following aspects of OSPFv3 auto-configuration are described:

1. Default OSPFv3 Configuration

2. HelloInterval/RouterDeadInterval Flexibility

3. Unique OSPFv3 Router-ID generation

4. OSPFv3 Adjacency Formation

5. Duplicate OSPFv3 Router-ID Resolution

1.1. 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 [RFC-KEYWORDS].

1.2. Acknowledgments

This specification was inspired by the work presented in the Homenet working group meeting in October 2011 in Philadelphia, Pennsylvania. In particular, we would like to thank Fred Baker, Lorenzo Colitti, Ole Troan, Mark Townsley, and Michael Richardson.

Arthur Dimitrelis and Aidan Williams did prior work in OSPFv3 auto-configuration in the expired "Autoconfiguration of routers using a link state routing protocol" IETF Draft. There are many similarities between the concepts and techniques in this document.

Thanks for Abhay Roy and Manav Bhatia for comments regarding duplicate router-id processing.

Thanks for Alvaro Retana and Michael Barnes for comments regarding OSPFv3 Instance ID auto-configuration.

Thanks to Faraz Shamim for review and comments.

Thanks to Mark Smith for the requirement to reduce the adjacency formation delay in the back-to-back ethernet topologies that are prevalent in home networks.

The RFC text was produced using Marshall Rose's xml2rfc tool.

2. OSPFv3 Default Configuration

For complete auto-configuration, OSPFv3 will need to choose suitable configuration defaults. These include:

1. Area 0 Only - All auto-configured OSPFv3 interfaces MUST be in area 0.

2. OSPFv3 SHOULD be auto-configured on for IPv6 on all interfaces intended as general IPv6-capable routers. Optionally, an interface MAY be excluded if it is clear that running OSPFv3 on the interface is not required. For example, if manual configuration or another condition indicates that an interface is connected to an Internet Service Provider (ISP) and there is no Border Gateway Protocol (BGP) [BGP] peering, there is typically no need to employ OSPFv3. However, note that in many environments it can be useful to test whether an OSPFv3 adjacency can be established. In home networking environments, an interface where no OSPFv3 neighbors are found but a DHCP IPv6 prefix can be acquired may be considered an ISP-facing interface and running OSPFv3 is unnecessary.

3. OSPFv3 interfaces will be auto-configured to an interface type corresponding to their layer-2 capability. For example, Ethernet interfaces and vanilla Wi-Fi interfaces will be auto-configured as OSPFv3 broadcast networks and Point-to-Point Protocol (PPP) interfaces will be auto-configured as OSPFv3 Point-to-Point interfaces. Most extant OSPFv3 implementations do this already. Auto-configured operation over wireless networks requiring a point-to-multipoint (P2MP) topology and dynamic metrics based on wireless feedback is not within the scope of this document. However, auto-configuration is not precluded in these environments.

4. OSPFv3 interfaces MAY use an arbitrary HelloInterval and RouterDeadInterval as specified in Section 3. Of course, an identical HelloInterval and RouterDeadInterval will still be required to form an adjacency with an OSPFv3 router not supporting auto-configuration [OSPFV3].

5. All OSPFv3 interfaces SHOULD be auto-configured to use an Interface Instance ID of 0 that corresponds to the base IPv6 unicast address family instance ID as defined in [OSPFV3-AF]. Similarly, if IPv4 unicast addresses are advertised in a separate auto-configured OSPFv3 instance, the base IPv4 unicast address family instance ID value, i.e., 64, SHOULD be auto-configured as the Interface Instance ID for all interfaces corresponding to the IPv4 unicast OSPFv3 instance [OSPFV3-AF].

3. OSPFv3 HelloInterval/RouterDeadInterval Flexibility

Auto-configured OSPFv3 routers will not require an identical HelloInterval and RouterDeadInterval to form adjacencies. Rather, the received HelloInterval will be ignored and the received RouterDeadInterval will be used to determine OSPFv3 liveliness with the sending router. In other words, the Neighbor Inactivity Timer (Section 10 of [OSPFV2]) for each neighbor will reflect that neighbor's advertised RouterDeadInterval and MAY be different from other OSPFv3 routers on the link without impacting adjacency formation. A similar mechanism requiring additional signaling is proposed for all OSPFv2 and OSPFv3 routers [ASYNC-HELLO].

3.1. Wait Timer Reduction

In many situations, auto-configured OSPFv3 routers will be deployed in environments where back-to-back ethernet connections are utilized. When this is the case, an OSPFv3 broadcast interface will not come up until the other OSPFv3 router is connected and the routers will wait RouterDeadInterval seconds before forming an adjacency [OSPFV2]. In order to reduce this delay, an auto-configured OSPFv3 router MAY reduce the wait interval to a value no less than (HelloInterval + 1). Reducing the setting will slightly increase the likelihood of the Designated Router (DR) flapping but is preferable to the long adjacency formation delay. Note that this value is not included in OSPFv3 Hello packets and does not impact interoperability.

4. OSPFv3 Router ID Selection

As OSPFv3 Router implementing this specification must select a unique Router ID. A pseudo-random number SHOULD be used for the OSPFv3 Router ID. The generation should be seeded with a variable that is likely to be unique in the applicable OSPFv3 router deployment. A good choice of seed would be some portion or hash of the Route-Hardware-Fingerprint as described in Section 6.2.2.

Since there is a possibility of a Router ID collision, duplicate Router ID detection and resolution are required as described in Section 6 and Section 6.3.

5. OSPFv3 Adjacency Formation

Since OSPFv3 uses IPv6 link-local addresses for all protocol messages other than messages sent on virtual links (which are not applicable to auto-configuration), OSPFv3 adjacency formation can proceed as soon as a Router ID has been selected and the IPv6 link-local address has completed Duplicate Address Detection (DAD) as specified in IPv6 Stateless Address Autoconfiguration [SLAAC]. Otherwise, the only changes to the OSPFv3 base specification are supporting HelloInterval/RouterDeadInterval flexibility as described in Section 3 and duplicate Router ID detection and resolution as described in Section 6 and Section 6.3.

6. OSPFv3 Duplicate Router ID Detection and Resolution

There are two cases of duplicate OSPFv3 Router ID detection. One where the OSPFv3 router with the duplicate Router ID is directly connected and one where it is not. In both cases, the duplicate resolution is for one of the routers to select a new OSPFv3 Router ID.

6.1. Duplicate Router ID Detection for Neighbors

In this case, a duplicate Router ID is detected if any valid OSPFv3 packet is received with the same OSPFv3 Router ID but a different IPv6 link-local source address. Once this occurs, the OSPFv3 router with the numerically smaller IPv6 link-local address will need to select a new Router ID as described in Section 6.3. Note that the fact that the OSPFv3 router is a neighbor on a non-virtual interface implies that the router is directly connected. An OSPFv3 router implementing this specification should assure that the inadvertent connection of multiple router interfaces to the same physical link is not misconstrued as detection of an OSPFv3 neighbor with a duplicate Router ID.

6.2. Duplicate Router ID Detection for OSPFv3 Routers that are not Neighbors

OSPFv3 Routers implementing auto-configuration, as specified herein, MUST originate an Auto-Configuration (AC) Link State Advertisement (LSA) including the Router-Hardware-Fingerprint Type-Length-Value (TLV). The Router-Hardware-Fingerprint TLV contains a variable length value that has a very high probability of uniquely identifying the advertising OSPFv3 router. An OSPFv3 router implementing this specification MUST compare a received self-originated Auto-Configuration LSA's Router-Hardware-Fingerprint TLV against its own router hardware fingerprint. If the fingerprints are not equal, there is a duplicate Router ID conflict and the OSPFv3 Router with the numerically smaller router hardware fingerprint MUST select a new Router ID as described in Section 6.3.

This new LSA is designated for information related to OSPFv3 Auto-configuration and, in the future, could be used other auto-configuration information, e.g., global IPv6 prefixes. However, this is beyond the scope of this document.

6.2.1. OSPFv3 Router Auto-Configuration LSA

The OSPFv3 Auto-Configuration (AC) LSA has a function code of TBD and the S2/S1 bits set to 01 indicating Area Flooding Scope. The U bit will be set indicating that the OSPFv3 AC LSA should be flooded even

if it is not understood. The Link State ID (LSID) value will be a integer index used to discriminate between multiple AC LSAs originated by the same OSPFv3 Router. This specification only describes the contents of an AC LSA with a Link State ID (LSID) of 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             |1|0|1|          TBD            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                       Link State ID                           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                       Advertising Router                      |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                       LS sequence number                      |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|        LS checksum            |             Length            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                                                               |
+-                            TLVs                             -+
|                             ...                               |
```

OSPFv3 Auto-Configuration (AC) LSA

The format of the TLVs within the body of an AC LSA is the same as the format used by the Traffic Engineering Extensions to OSPF [TE]. The LSA payload consists of one or more nested Type/Length/Value (TLV) triplets. The format of each TLV is:

```
 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|              Type             |             Length            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                            Value...                           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

TLV Format

The Length field defines the length of the value portion in octets (thus a TLV with no value portion would have a length of 0). The TLV is padded to 4-octet alignment; padding is not included in the length

field (so a 3-octet value would have a length of 3, but the total size of the TLV would be 8 octets). Nested TLVs are also 32-bit aligned. For example, a 1-byte value would have the length field set to 1, and 3 octets of padding would be added to the end of the value portion of the TLV. Unrecognized types are ignored.

The new LSA is designated for information related to OSPFv3 Auto-configuration and, in the future, can be used other auto-configuration information.

6.2.2. Router-Hardware-Fingerprint TLV

The Router-Hardware-Fingerprint TLV is the first TLV defined for the OSPFv3 Auto-Configuration (AC) LSA. It will have type 1 and MUST be advertised in the LSID OSPFv3 AC LSA with an LSID of 0. It SHOULD occur, at most, once and the first instance of the TLV will take precedence over subsequent TLV instances. The length of the Router-Hardware-Fingerprint is variable but must be 32 octets or greater.

The contents of the hardware fingerprint SHOULD be some combination of MAC addresses, CPU ID, or serial number(s) that provides an extremely high probability of uniqueness. It MUST be based on hardware attributes that will not change across hard and soft restarts.

```
  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
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |              1                |            >32                |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |           Router Hardware Fingerprint                         |
                         o
                         o
                         o
 |                                                               |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Router-Hardware-Fingerprint TLV Format

6.3. Duplicate Router ID Resolution

The OSPFv3 Router selected to resolve the duplicate OSPFv3 Router ID condition must select a new OSPFv3 Router ID. After selecting a new Router ID, all self-originated LSAs MUST be reoriginated, and any OSPFv3 neighbor adjacencies MUST be reestablished. The OSPFv3 router

retaining the Router ID causing the conflict will reoriginate or purge stale any LSAs as described in Section 13.4 [OSPFV2].

6.4. Change to RFC 2328 Section 13.4, 'Receiving Self-Originated LSA' Processing

RFC 2328 [OSPFV2], Section 13.4, describes the processing of received self-originated LSAs. If the received LSA doesn't exist, the receiving router will purge it from the OSPF routing domain. If the LSA is newer than the version in the Link State Database (LSDB), the receiving router will originate a newer version by advancing the LSA sequence number and reflooding. Since it is possible for an auto-configured OSPFv3 router to choose a duplicate OSPFv3 Router ID, OSPFv3 routers implementing this specification should detect when multiple instances of the same self-originated LSA are purged or reoriginated since this is indicative of an OSPFv3 router with a duplicate Router ID in the OSPFv3 routing domain. When this condition is detected, the OSPFv3 Router SHOULD delay self-originated LSA processing for LSAs that have recently been purged or reflooded. This specification recommends 10 seconds as the interval defining recent self-originated LSA processing and an exponential back off of 1 to 8 seconds for the processing delay. This additional delay should allow for the mechanisms described in Section 6 to resolve the duplicate OSPFv3 Router ID conflict.

7. Security Considerations

A unique OSPFv3 Interface Instance ID is used for auto-configuration to prevent inadvertent OSPFv3 adjacency formation, see Section 2

The goals of security and complete OSPFv3 auto-configuration are somewhat contradictory. When no explicit security configuration takes place, auto-configuration implies that additional devices placed in the network are automatically adopted as a part of the network. However, auto-configuration can also be combined with password configuration (see below) or future extensions for automatic pairing between devices. These mechanisms can help provide an automatically configured, securely routed network.

It is RECOMMENDED that OSPFv3 routers supporting this specification also offer an option to explicitly configure a password for HMAC-SHA authentication as described in [OSPFV3-AUTH-TRAILER]. When configured, the password will be used on all auto-configured interfaces with the Security Association Identifier (SA ID) set to 1 and HMAC-SHA-256 used as the authentication algorithm.

8. Management Considerations

It is RECOMMENDED that OSPFv3 routers supporting this specification also allow explicit configuration of OSPFv3 parameters as specified in Appendix C of [OSPFV3]. This is in addition to the authentication key configuration recommended in Section 7. However, it is acknowledged that there may be some deployment scenarios where manual authentication key configuration is not required.

9. IANA Considerations

This specification defines an OSPFv3 LSA Type for the OSPFv3 Auto-Configuration (AC) LSA, as described in Section 6.2.1. The value TBD will be allocated from the existing "OSPFv3 LSA Function Code" registry for the OSPFv3 Auto-Configuration LSA.

This specification also creates a registry for OSPFv3 Auto-Configuration (AC) LSA TLVs. This registry should be placed in the existing OSPFv3 IANA registry, and new values can be allocated via IETF Consensus or IESG Approval.

Three initial values are allocated:

- 0 is marked as reserved.

- 1 is Router-Hardware-Fingerprint TLV (Section 6.2.2).

- 65535 is an Auto-configuration-Experiment-TLV, a common value that can be used for experimental purposes.

10. References

10.1. Normative References

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[OSPFV3] Coltun, R., Ferguson, D., Moy, J., and A. Lindem, "OSPF for IPv6", RFC 5340, July 2008.

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10.2. Informative References

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