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## Use of OSPF-MDR in Single-Hop Broadcast Networks

### Abstract

RFC 5614 (OSPF-MDR) extends OSPF to support mobile ad hoc networks (MANETs) by specifying its operation on the new OSPF interface of type MANET. This document describes the use of OSPF-MDR (MANET Designated Router) in a single-hop broadcast network, which is a special case of a MANET in which each router is a (one-hop) neighbor of each other router. Unlike an OSPF broadcast interface, such an interface can have a different cost associated with each neighbor. The document includes configuration recommendations and simplified mechanisms that can be used in single-hop broadcast networks.

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## 1. Introduction

OSPF-MDR [RFC5614] specifies an extension of OSPF [RFC2328, RFC5340] to support mobile ad hoc networks (MANETs) by specifying its operation on the new OSPF interface of type MANET. OSPF-MDR generalizes the Designated Router (DR) to a connected dominating set (CDS) consisting of a typically small subset of routers called MANET Designated Routers (MDRs). Similarly, the Backup Designated Router (BDR) is generalized to a subset of routers called Backup MDRs (BMDRs). MDRs achieve scalability in MANETs similar to the way DRs achieve scalability in broadcast networks:

- o MDRs have primary responsibility for flooding the Link State Advertisements (LSAs). Backup MDRs provide backup flooding when MDRs temporarily fail.
- o MDRs allow the number of adjacencies to be dramatically reduced by requiring adjacencies to be formed only between MDR/BMDR routers and their neighbors.

In addition, OSPF-MDR has the following features:

- o MDRs and BMDRs are elected based on information obtained from modified Hello packets received from neighbors.
- o If adjacency reduction is used (the default), adjacencies are formed between MDRs so as to form a connected subgraph. An option (AdjConnectivity = 2) allows for additional adjacencies to be formed between MDRs/BMDRs to produce a biconnected subgraph.
- o Each non-MDR router becomes adjacent with an MDR called its Parent, and optionally (if AdjConnectivity = 2) becomes adjacent with another MDR or BMDR called its Backup Parent.

- o Each router advertises connections to its neighbor routers as point-to-point links in its router-LSA. Network-LSAs are not used.
- o In addition to full-topology LSAs, partial-topology LSAs may be used to reduce the size of router-LSAs. Such LSAs are formatted as standard LSAs, but advertise links to only a subset of neighbors.
- o Optionally, differential Hellos can be used, which reduce overhead by reporting only changes in neighbor states.

This document describes the use of OSPF-MDR in a single-hop broadcast network, which is a special case of a MANET in which each router is a (one-hop) neighbor of each other router. An understanding of [RFC5614] is assumed. Unlike an OSPF broadcast interface, such an interface can have a different cost associated with each neighbor. An example use case is when the underlying radio system performs layer-2 routing but has a different number of (layer-2) hops to (layer-3) neighbors.

The rationale for using this interface type for single-hop broadcast networks, instead of a broadcast interface type, is to represent the underlying network in a point-to-multipoint manner, allowing each router to advertise different costs to different neighbors in its router-LSA. In this sense, this document shows how the OSPF-MDR interface type can be configured (and simplified if desired) to achieve the same goals as the OSPF Hybrid Broadcast and Point-to-Multipoint interface type [RFC6845].

Section 2 describes the operation of OSPF-MDR in a single-hop broadcast network with recommended parameter settings. Section 3 describes an alternative procedure that may be used to decide which neighbors on a single-hop broadcast network to advertise in the router-LSA. Section 4 describes a simplified version of the MDR selection algorithm for single-hop networks.

The alternative procedure of Section 3 and the simplified algorithm of Section 4 are optional and MUST NOT be used if it is possible for two routers in the network to be more than one hop from each other.

### 1.1. Terminology

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. Operation in a Single-Hop Broadcast Network

When OSPF-MDR is used in a single-hop broadcast network, the following parameter settings and options (defined in [RFC5614]) should be used:

- o AdjConnectivity SHOULD be equal to 2 (biconnected); this provides the smoothest transition when one router replaces another as MDR, since the set of adjacencies forms a biconnected network that remains connected during the transition.
- o AdjConnectivity MAY be equal to 1 (unconnected), resulting in a slightly less smooth transition, since adjacencies must be formed between the new MDR and all of its neighbors.
- o AdjConnectivity SHOULD NOT be equal to 0 (full topology), since this requires adjacencies to be formed between all pairs of routers, adding unnecessary message overhead.
- o An adjacency SHOULD be eliminated if neither the router nor the neighbor is an MDR or BMDR (see Section 7.3 of [RFC5614]).
- o LSAPFullness MUST be equal to 4 or 5 if full-topology LSAs are required. (The value 5 is defined in Section 3 of this document.)
- o LSAPFullness MAY be equal to 1 (min-cost LSAs) if full-topology LSAs are not required. This option reduces the number of advertised links while still providing shortest paths.

If AdjConnectivity equals 1 or 2 and full-topology LSAs are used, OSPF-MDR running on a single-hop broadcast network has the following properties:

- o A single MDR is selected, which becomes adjacent with every other router, as in an OSPF broadcast network.
- o Two BMDRs are selected. This occurs because the MDR selection algorithm ensures that the MDR/BMDR backbone is biconnected. If AdjConnectivity = 2, every non-MDR/BMDR router becomes adjacent with one of the BMDRs in addition to the MDR.
- o When all adjacencies are fully adjacent, the router-LSA for each router includes point-to-point (type 1) links to all bidirectional neighbors (in state 2-Way or greater).

### 3. Originating Router-LSAs

A router running OSPF-MDR with LSAPFullness = 4 includes in its router-LSA point-to-point (type 1) links for all fully adjacent neighbors, and for all bidirectional neighbors that are routable. A neighbor is routable if the SPF calculation has produced a route to the neighbor and a flexible quality condition is satisfied.

This section describes an alternative procedure that MAY be used instead of the procedure described in Section 6 of [RFC5614], to decide which neighbors on a single-hop broadcast network to advertise in the router-LSA. The alternative procedure will correspond to LSAPFullness = 5, and is interoperable with the other choices for LSAPFullness. This procedure avoids the need to check whether a neighbor is routable, and thus avoids having to update the set of routable neighbors.

If LSAPFullness = 5, then the Selected Advertised Neighbor Set (SANS) is the same as specified for LSAPFullness = 4, and the following steps are performed instead of the first paragraph of Section 9.4 in [RFC5614].

- (1) The MDR includes in its router-LSA a point-to-point (type 1) link for each fully adjacent neighbor. (Note that the MDR becomes adjacent with all of its neighbors.)
- (2) Each non-MDR router includes in its router-LSA a point-to-point link for each fully adjacent neighbor, and, if the router is fully adjacent with the MDR, for each bidirectional neighbor *j* such that the MDR's router-LSA includes a link to *j*.

To provide rationale for the above procedure, let *i* and *j* be two non-MDR routers. Since the SPF calculation (Section 16.1 of [RFC2328]) allows router *i* to use router *j* as a next hop only if router *j* advertises a link back to router *i*, routers *i* and *j* must both advertise a link to each other in their router-LSAs before either can use the other as a next hop. Therefore, the above procedure for non-MDR routers (Step 2) implies there must exist a path of fully adjacent links between *i* and *j* (via the MDR) in both directions before this can happen. The above procedure for non-MDR routers is similar to one described in Section 4.6 of [RFC6845] for non-DR routers.

#### 4. MDR Selection Algorithm

The MDR selection algorithm of [RFC5614] simplifies as follows in single-hop networks. The resulting algorithm is similar to the DR election algorithm of OSPF, but is slightly different (e.g., two Backup MDRs are selected). The following simplified algorithm is interoperable with the full MDR selection algorithm.

Note that lexicographic order is used when comparing tuples of the form (RtrPri, MDR Level, RID). Also note that each router will form adjacencies with its Parents and dependent neighbors. In the following, the term "neighbor" refers to a bidirectional neighbor (in state 2-Way or greater).

Phase 1: Creating the neighbor connectivity matrix is not required.

Phase 2: MDR Selection

- (2.1) The set of Dependent Neighbors is initialized to be empty.
- (2.2) If the router has a larger value of (RtrPri, MDR Level, RID) than all of its (bidirectional) neighbors, the router selects itself as an MDR; selects its BMDR neighbors as Dependent Neighbors if AdjConnectivity = 2; then proceeds to Phase 4.
- (2.3) Otherwise, if the router's MDR Level is currently MDR, then it is changed to BMDR before executing Phase 3.

Phase 3: Backup MDR Selection

- (3.1) Let Rmax be the neighbor with the largest value of (RtrPri, MDR Level, RID).
- (3.2) Determine whether or not there exist two neighbors, other than Rmax, with a larger value of (RtrPri, MDR Level, RID) than the router itself.
- (3.3) If there exist two such neighbors, then the router sets its MDR Level to MDR Other.
- (3.4) Else, the router sets its MDR Level to BMDR, and if AdjConnectivity = 2, adds Rmax and its MDR/BMDR neighbors as Dependent Neighbors.
- (3.5) If steps 3.1 through 3.4 resulted in the MDR Level changing from MDR Other to BMDR, then execute Step 2.2 again before proceeding to Phase 4. (This is necessary because running Step 2.2 again can cause the MDR Level to change to MDR.)

#### Phase 4: Parent Selection

Each router selects a Parent and (if AdjConnectivity = 2) a Backup Parent for the single-hop broadcast network. The Parent for a non-MDR router will be the MDR. The Backup Parent for an MDR Other, if it exists, will be a BMDR. Each non-MDR router becomes adjacent with its Parent and its Backup Parent, if it exists. The Parent selection algorithm is already simple, so a simplified version is not given here.

The Parent and Backup Parent are analogous to the Designated Router and Backup Designated Router interface data items in OSPF. As in OSPF, these are advertised in the DR and Backup DR fields of each Hello sent on the interface.

#### 5. Security Considerations

This document describes the use of OSPF-MDR in a single-hop broadcast network, and raises no security issues in addition to those already covered in [RFC5614].

#### 6. Normative References

- [RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, March 1997.
- [RFC2328] Moy, J., "OSPF Version 2", STD 54, RFC 2328, April 1998.
- [RFC5340] Coltun, R., Ferguson, D., Moy, J., and A. Lindem, "OSPF for IPv6", RFC 5340, July 2008.
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#### 7. Informative References

- [RFC6845] Sheth, N., Wang, L., and J. Zhang, "OSPF Hybrid Broadcast and Point-to-Multipoint Interface Type", RFC 6845, January 2013.

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