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A RPL DODAG Configuration Option for the 6LoWPAN Routing Header
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Abstract

This document updates RFC 8138 by defining a bit in the RPL DODAG Configuration Option to indicate whether compression is used within the RPL Instance, and specify the behavior of RFC 8138-capable nodes when the bit is set and reset.

Status of This Memo

This Internet-Draft is submitted in full conformance with the provisions of BCP 78 and BCP 79.

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This Internet-Draft will expire on 6 February 2021.

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1. Introduction

The packet compression technique defined in [RFC8138] can only be activated in a RPL [RFC6550] network when all the nodes support it. Otherwise, a non-capable node acting as leaf-only would fail to communicate, and acting as a router it would drop the compressed packets and black-hole a portion of the network.

The original idea was to use a flag day but that proved impractical in a number of situations such as a large metering network that is used in production and incurs financial losses when interrupted.

This specification is designed for the scenario where a live network is upgraded to support [RFC8138]. During the migration, the compression should remain inactive, until all nodes are upgraded. This document complements [RFC8138] and dedicates a flag in the RPL DODAG Configuration Option to indicate whether the [RFC8138] compression should be used within the RPL DODAG.

The setting of this new flag is controlled by the Root and propagates as is in the whole network as part of the normal RPL signaling.

The idea is to use the flag to maintain the compression inactive

during the migration phase. When the migration is complete (e.g., as known by network management and/or inventory), the flag is set and the compression is globally activated in the whole DODAG.

2. Terminology

2.1. References

The terminology used in this document is consistent with and incorporates that described in "Terms Used in Routing for Low-Power and Lossy Networks (LLNs)" [RFC7102]. Other terms in use in LLNs are found in "Terminology for Constrained-Node Networks" [RFC7228].

"RPL", the "RPL Packet Information" (RPI), and "RPL Instance" (indexed by a RPLInstanceID) are defined in "RPL: IPv6 Routing Protocol for Low-Power and Lossy Networks" [RFC6550]. The RPI is the abstract information that RPL defines to be placed in data packets, e.g., as the RPL Option [RFC6553] within the IPv6 Hop-By-Hop Header. By extension the term "RPI" is often used to refer to the RPL Option itself. The DODAG Information Solicitation (DIS), Destination Advertisement Object (DAO) and DODAG Information Object (DIO) messages are also specified in [RFC6550].

This document uses the terms RPL-Unaware Leaf (RUL) and RPL-Aware Leaf (RAL) consistently with "Using RPI Option Type, Routing Header for Source Routes and IPv6-in-IPv6 encapsulation in the RPL Data Plane" [USEofRPLinfo]. The term RPL-Aware Node (RAN) refers to a node that is either a RAL or a RPL Router. A RAN manages the reachability of its addresses and prefixes by injecting them in RPL by itself. In contrast, a RUL leverages "Registration Extensions for IPv6 over Low-Power Wireless Personal Area Network (6LoWPAN) Neighbor Discovery" [RFC8505] to obtain reachability services from its parent router(s) as specified in "Routing for RPL Leaves" [UNAWARE-LEAVES].

2.2. Glossary

This document often uses the following acronyms:

6LoWPAN: IPv6 over Low-Power Wireless Personal Area Network
6LoRH: 6LoWPAN Routing Header

DIO: DODAG Information Object (a RPL message)
DODAG: Destination-Oriented Directed Acyclic Graph
LLN: Low-Power and Lossy Network
RPL: IPv6 Routing Protocol for Low-Power and Lossy Networks
OF: RPL Objective Function
OCP: RPL Objective Code Point
MOP: RPL Mode of Operation
RPI: RPL Packet Information
RAL: RPL-Aware Leaf
RAN: RPL-Aware Node
RUL: RPL-Unaware Leaf
SRH: Source Routing Header

2.3. Requirements Language

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 BCP 14 [RFC2119][RFC8174] when, and only when, they appear in all capitals, as shown here.

3. The RPL DODAG Configuration Option

The DODAG Configuration Option is defined in Section 6.7.6 of [RFC6550].

The RPL DODAG Configuration Option is typically placed in a DODAG Information Object (DIO) message. The DIO message propagates down the DODAG to form and then maintain its structure. The DODAG Configuration Option is copied unmodified from parents to children.

As shown in Figure 1, the DODAG Configuration Option was designed with 4 bit positions reserved for future use as Flags.

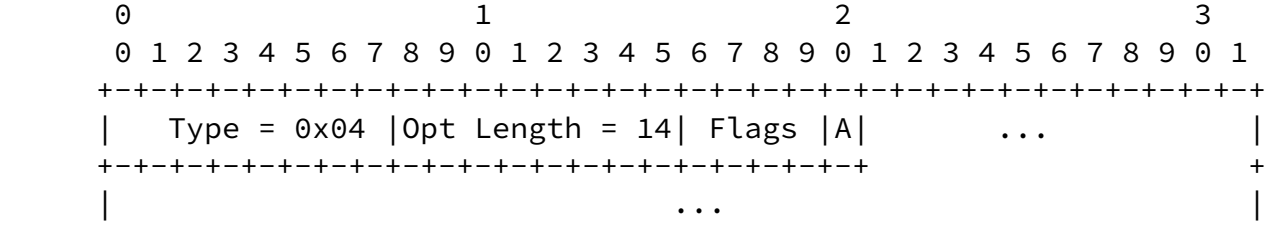

Figure 1: DODAG Configuration Option (Partial View)

This specification defines a new flag "Enable RFC8138 Compression" (T). The "T" flag is set to turn-on the use of the compression of RPL artifacts with [RFC8138] within the DODAG. The new "T" flag is encoded in the Flags field in the RPL DODAG Configuration Option. The suggested bit position of the "T" flag is indicated in Section 6.

[RFC6550] states, when referring to the DODAG Configuration Option, that "Nodes other than the DODAG Root MUST NOT modify this information when propagating the DODAG Configuration option". Therefore, a legacy parent propagates the "T" flag as set by the Root whether it supports this specification or not. So when the "T" flag is set, it is transparently flooded to all the nodes in the DODAG.

Section 6.3.1 of [RFC6550] defines a 3-bit Mode of Operation (MOP) in the DIO Base Object. This specification applies to MOP values 0 to 6. For a MOP value of 7, the compression MUST be used by default regardless of the setting of the "T" flag.

4. Updating RFC 8138

A node SHOULD source packets in the compressed form using [RFC8138] if and only if the "T" flag is set. This behaviour can be overridden by e.g., configuration or network management. Overriding may be needed e.g., to cope with a legacy implementation of the Root that supports [RFC8138] but not this specification and cannot set the "T" flag.

The decision of using [RFC8138] is made by the originator of the packet depending on its capabilities and its knowledge of the state of the "T" flag. A router that encapsulates a packet is the originator of the resulting packet and is responsible to compress the outer headers with [RFC8138], but it MUST leave the encapsulated packet as is.

An external target [USEofRPLinfo] is not expected to support [RFC8138]. In most cases, packets from and to an external target are tunneled back and forth between the border router (referred to as 6LR) that serves the external target and the Root, regardless of the MOP used in the RPL DODAG. The inner packet is typically not compressed with [RFC8138], so for outgoing packets, the border router

just needs to decapsulate the (compressed) outer header and forward the (uncompressed) inner packet towards the external target.

A router MUST uncompress a packet that is to be forwarded to an external target. Otherwise, the router MUST forward the packet in the form that the source used, either compressed or uncompressed.

A RUL [UNAWARE-LEAVES] is both a leaf and an external target. A RUL does not participate in RPL and depends on the parent router to obtain connectivity. In the case of a RUL, forwarding towards an external target actually means delivering the packet.

5. Transition Scenarios

A node that supports [RFC8138] but not this specification can only be used in an homogeneous network. Enabling the [RFC8138] compression without a turn-on signaling requires a "flag day"; all nodes must be upgraded, and then the network can be rebooted with the [RFC8138] compression turned on.

The intent for this specification is to perform a migration once and for all without the need for a flag day. In particular it is not the intention to undo the setting of the "T" flag. Though it is possible to roll back (see Section 5.3), adding nodes that do not support [RFC8138] after a roll back may be problematic if the roll back did not fully complete.

5.1. Coexistence

A node that supports this specification can operate in a network with the [RFC8138] compression turned on or off with the "T" flag set accordingly and in a network in transition from off to on or on to off (see Section 5.2).

A node that does not support [RFC8138] can interoperate with nodes that do in a network with [RFC8138] compression turned off. If the compression is turned on, all the RPL-Aware Nodes are expected to be able to handle compressed packets in the compressed form. A node that cannot do so may remain connected to the network as a RUL, but how the node is modified to turn into a RUL is out of scope.

5.2. Inconsistent State While Migrating

When the "T" flag is turned on by the Root, the information slowly percolates through the DODAG as the DIO gets propagated. Some nodes will see the flag and start sourcing packets in the compressed form while other nodes in the same RPL DODAG are still not aware of it. In non-storing mode, the Root will start using [RFC8138] with a Source Routing Header 6LoRH (SRH-6LoRH) that routes all the way to the parent router or to the leaf.

To ensure that a packet is forwarded across the RPL DODAG in the form in which it was generated, it is required that all the RPL nodes support [RFC8138] at the time of the switch.

Setting the "T" flag is ultimately the responsibility of the Network Administrator. The expectation is that the network management or upgrading tools in place enable the Network Administrator to know when all the nodes that may join a DODAG were migrated. In the case of a RPL instance with multiple Roots, all nodes that participate to the RPL Instance may potentially join any DODAG. The network MUST be operated with the "T" flag reset until all nodes in the RPL Instance are upgraded to support this specification.

5.3. Rolling Back

When turning [RFC8138] compression off in the network, the Network Administrator MUST wait until all nodes have converged to the "T" flag reset before allowing nodes that do not support the compression in the network.

It is RECOMMENDED to only deploy nodes that support [RFC8138] in a network where the compression is turned on. A node that does not support [RFC8138] MUST only be used as a RUL.

6. IANA Considerations

IANA is requested to assign a new option flag from the Registry for the "DODAG Configuration Option Flags" that was created for [RFC6550] as follows:

Bit Number	Capability Description	Reference

2 (suggested)	Turn on RFC8138 Compression (T)	THIS RFC

Table 1: New DODAG Configuration Option Flag

7. Security Considerations

First of all, it is worth noting that with [RFC6550], every node in the LLN that is RPL-aware can inject any RPL-based attack in the network. A trust model has to be put in place in an effort to exclude rogue nodes from participating to the RPL and the 6LoWPAN signaling, as well as from the data packet exchange. This trust model could be at a minimum based on a Layer-2 Secure joining and the Link-Layer security. This is a generic RPL and 6LoWPAN requirement, see Req5.1 in Appendix of [RFC8505].

Setting the "T" flag before all routers are upgraded may cause a loss of packets. The new bit is protected as the rest of the configuration so this is just one of the many attacks that can happen if an attacker manages to inject a corrupted configuration.

Setting and resetting the "T" flag may create inconsistencies in the network but as long as all nodes are upgraded to [RFC8138] support they will be able to forward both forms. The source is responsible for selecting whether the packet is compressed or not, and all routers must use the format that the source selected. So the result of an inconsistency is merely that both forms will be present in the network, at an additional cost of bandwidth for packets in the uncompressed form.

An attacker in the middle of the network may reset the "T" flag to cause extra energy spending in its subDAG. Conversely it may set the "T" flag, so that nodes located downstream would compress when that it is not desired, potentially resulting in the loss of packets. In a tree structure, the attacker would be in position to drop the packets from and to the attacked nodes. So the attacks above would be more complex and more visible than simply dropping selected packets. The downstream node may have other parents and see both settings, which could raise attention.

8. Acknowledgments

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