A DODAG Metric Used for DODAG Selection in Low-Power and Lossy Networks

Abstract

This document extends [RFC6551] by defining a new DODAG metric
called DODAG size, which can be used for DODAG selection in Low-
Power and Lossy Networks (LLNs). DODAG size is an important metric
for nodes to decide which DODAG to join, or which DODAG to migrate.
This document proposes methods to disseminate DODAG size from the
Root to all nodes in the DODAG, so that the DODAG size can be
advertised to new joining nodes.

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1. Introduction

Low-power and Lossy Networks (LLNs) typically consist of large
number of nodes connected by lossy and unstable links. Such networks
are typically compised of nodes that are constrained in CPU power,
memory, and energy.

RPL, the "Routing Protocol for LLNs" [RFC6550], is an IPv6 routing
procotol with specific optimizations for such networks. RPL builds
routes proactively but maintains them on-demand based on their
utilization. Point-to-multipoint (P2MP) and multipoint-to-point
(MP2P) routes to and from the Root are optimized, but other point-
to-point (P2P) routes are stretched to minimize the control traffic
and the state in every node.

When used in conjunction with IEEE Std. 802.15.4 [IEEE802154], RPL
can be used to form a Personal Area Network (PAN) composed by a
6LoWPAN Border Router (6LBR) that is typically collocated with the
DODAG Root, and multiple 6LoWPAN Nodes (6LN), that can be RPL
routers of leaves.

The PAN formation process starts from a DODAG Root. Before a node
joins a PAN, it has no information regarding available neighbors or
PANs. To discover available PANs, a joining node transmits PAN
Advertisement Solicits and listens for PAN Advertisements from
either the Root or other joined nodes.

The PAN Advertisements contain minimum information (such as network
name, DODAG size, etc.) for a node to select an appropriate PAN to
join or migrate. The DODAG size is the number of nodes in the DODAG
and communicating through the Root. The DODAG size thus is an

important metric for a node to decide which PAN to join. Therefore, it is essential to ensure the value of DODAG size advertised is up-to-date.

At this early stage, this document propose two methods to disserminates the DODAG size to the PAN.

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 [RFC6551] 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].

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: Directed Acyclic Graph
DODAG: Destination-Oriented Directed Acyclic Graph
LLN: Low-Power and Lossy Network
PAN: Personal Area Network
RPL: IPv6 Routing Protocol for Low-Power and Lossy Networks

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. Disseminating DODAG size

The value of DODAG size is collected by the Root, and disseminated
to all nodes in the PAN. To ensure timely delivering of DODAG size,
it has to be contained in periodic PAN-wide messages that can reach
every node in the PAN.

The DODAG size is defined by the DODAG Size Object and MAY be
present in the DODAG Metric Container option [RFC6551].

3.1. DODAG Size Object

[RFC6551] specifies a set of link and node routing metrics and
constraints suitable to LLNs. This document extends [RFC6551] by
defining a new DODAG metric called DODAG size.

The DODAG size object MAY be present in the DODAG Metric Container.
There MUST NOT be more than one DODAG size object as a metric per
DODAG Metric Container.

The DODAG size object is made of DODAG size fields and MUST at least
comprise one DODAG size field. Each DODAG size field has a fixed
length of 16 bits.

The DODAG size object does not contain any additional TLVs.

The DODAG size object Type has been assigned value TBD by IANA.

The format of the ETX object body is as follows:

```
             0                   1
              0 1 2 3 4 5 6 7 8 9 0 1 2 3
             +-+-+-+-+-+-+-+-+-+-+-+-+-+-+
             |  (field) .....        |
             +-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```
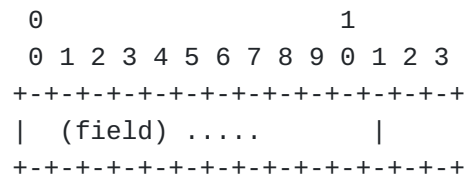
                Figure 1: DODAG Size Object Body Format

```
             0                       1
              0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5
             +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
             |               DODAG Size          |
             +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```
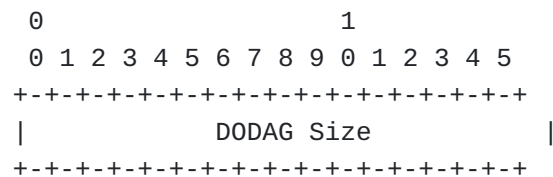
                 Figure 2: DODAG Size field Format

DODAG Size: 16 bits. It is encoded using 16 bits in unsigned integer format.

3.2. Disserminating DODAG size through DIO

According to [RFC6550], the DIO message is periodically sent to the PAN, and it MAY carry an option called DODAG Metric Container. The DODAG size object can be present in this option. Through the DIO message, the DODAG size is gradually disseminated to nodes in the PAN

3.3. Disserminating DODAG size through DAO-ACK

The DAO-ACK message [RFC6550] is sent as unicast packet by the DODAG Root in response to a unicast DAO message.

It MAY carry the DODAG Metric Container option [RFC6550]. The DODAG size MAY be present in the DODAG Metric Container option.

The nodes in a PAN might be able to get the DODAG size timely through the DAO-ACK messsage.. Compared with the DIO message, the DAO-ACK message is tyipcally sent more frequently. Moreover, nodes deep in the DODAG can get the DODAG size more quickly since the DAO-ACK is directly sent by the Root in unicast.

4. IANA Considerations

This specification updates the "Routing Metric/Constraint Type" subregistry of the "Routing Protocol for Low Power and Lossy Networks (RPL) Routing Metric/Constraint" Registry that was created for [RFC6551].

IANA is thereby requested to allocate one new value as follows:

Value	Description	Reference
9 (suggested)	DODAG size	This document

Table 1: New DODAG Metric Object Type

5. Security Considerations

It is worth noting that in RPL [RFC6550], every node in the LLN that is RPL-aware and has access to the RPL domain can inject any RPL-based attack in the network, more in [RFC7416]. This document applies typically to an existing deployment and does not change its security requirements and operations. It is assumed that the security mechanisms as defined for RPL are followed.

6. Acknowledgments

The authors wish to thank TBD.

7. Normative References

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Authors' Addresses

Huimin She
Cisco Systems, Inc
Xinsi Building
No. 926 Yishan Road, Xuhui District
SHANGHAI
200233
China

Email: hushe@cisco.com

Li Zhao
Cisco Systems, Inc
Xinsi Building
No. 926 Yishan Road, Xuhui District
SHANGHAI
200233
China

Email: liz3@cisco.com

Pascal Thubert
Cisco Systems, Inc
Building D
45 Allee des Ormes - BP1200
06254 MOUGINS - Sophia Antipolis
France

Phone: +33 497 23 26 34
Email: pthubert@cisco.com