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RPL adaptation for asymmetrical links  
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## Abstract

The Routing Protocol for Low Power and Lossy Networks defines a generic Distance Vector protocol for Low Power and Lossy Networks, many of which exhibit strongly asymmetrical characteristics. This draft proposes an extension for that optimizes RPL operations whereby upwards and downwards direction-optimized RPL instances are associated.

## Requirements Language

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 2119](#) [[RFC2119](#)].

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## 1. Introduction

The IETF ROLL Working Group has defined application-specific routing requirements for a Low Power and Lossy Network (LLN) routing protocol, specified in [\[RFC5548\]](#), [\[RFC5673\]](#), [\[RFC5826\]](#), and [\[RFC5867\]](#), many of which explicitly or implicitly refer to links with asymmetrical properties.

Upon those requirements, the Routing Protocol for Low Power and Lossy Network [\[I-D.ietf-roll-rpl\]](#) was designed as a platform that can be extended by further specification or guidance, by adding new metrics, Objective Functions, or additional options.

RPL forms Destination Oriented Directed Acyclic Graphs (DODAGs) within instances of the protocol. Each instance is associated with an Objective Function that is designed to solve the problem that is addressed by that instance.

On one hand, RPL requires bi-directional links for the control, but on the other hand, there is no requirement that the properties of a link are the same in both directions. In fact, a perfect symmetry is rarely present in Low Power and Lossy Networks (LLNs) such as wireless radio or power-line links.

Some initial implementations require that the quality of both directions of a link is evaluated as operational at an acceptable level so that the link can be used for control and data in both directions. This eliminates asymmetrical links that are not operational at an acceptable level in one direction.

In practice, a DAG that is built to optimize upwards traffic is generally not congruent with a DAG that is built to optimize downwards traffic. This is why this specification is designed to enable asymmetrical routing DAGs that are bound together to get the maximum benefits of all types of bi-directional links.

## [2.](#) Terminology

The terminology used in this document is consistent with and incorporates that described in 'Terminology in Low power And Lossy Networks' [[I-D.ietf-roll-terminology](#)] and [[I-D.ietf-roll-rpl](#)].

The term upwards qualifies a link, a DODAG or a RPL instance that is optimal for sending traffic towards the root, though may be usable but suboptimal for traffic coming from the direction of the root. The term downwards qualifies the same wording, only for opposite directions.

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The term parenting applied to instances refers to the directional association of two instances. The meta graph formed by parented instances must be a DAG. Traffic may be transferred from an instance onto a parent instance under specified circumstances.

The draft also uses the following terminology:

**bi-directional:** A link is bi-directional when traffic is confirmed possible in both directions, in a fashion that is sufficient to operate RPL control.

**asymmetric:** A link is asymmetric if it is bi-directional, yet exhibits major differences in link characteristics for both directions.

## [3.](#) The Asymmetrical Link Problem

## [4.](#) Solution Overview

With the core RPL specification, [[I-D.ietf-roll-rpl](#)] each instance is a separate routing topology, and packets must be forwarded within the same topology / same instance. One direct consequence of that design choice is that a topology must be operational at an acceptable level for both upwards and downwards traffic; otherwise, traffic between two nodes in the RPL instance may suffer.

RPL is designed to operate on bi-directional links. When the link

properties do not widely differ between the upwards and the downwards directions, a single DAG is adequate as the routing topology for both upwards and downwards traffic. In that case, an asymmetrical link, that can only be used for traffic in one direction, cannot participate to the routing topology. This results in an sub-optimal bandwidth utilization and/or a reduction of the possible path diversity.

This issue can be addressed with [[I-D.ietf-roll-rpl](#)], by constructing two DAGs, one that is used for upwards traffic and one that is used for downwards traffic. This solves the issue for all traffic that transits through the root of the DODAG, whether it is originated in the DODAG going out or is injected into the DODAG from the outside, since in both cases a packet will mostly use the asymmetric links in the appropriate direction.

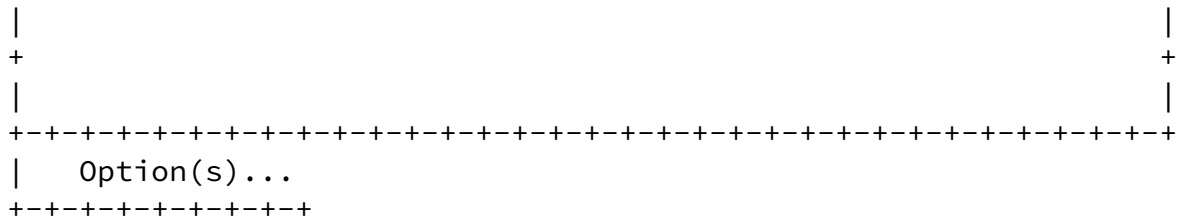
On the other hand, with RPL as it is specified, a packet follows the topology that is generated for its instance all the way through a DAG, and transferring a packet from an instance to another is not

permitted. As a result, the 2 DAGs solution would penalize Peer to peer traffic that would have to go through the root in order to leave the upward instance and then reenter at the root in order to join the downwards instance. This is not an issue in non-storing mode since the packet has to go through the root to load the routing header downwards anyway, but going through the root stretches the path in storing mode.

In order to benefit from both instances and yet avoid extra stretch through the root in storing mode, it is required to extend RPL rules so as to allow traffic to be transferred from one instance to the next before reaching the root on the way up. This document specifies conditions under which 2 instances can be bound together so that a node may transfer traffic from a RPL instance onto another, e.g. from an upwards RPL instance onto the downwards RPL instance.

It can be noted at this point that with [[I-D.ietf-roll-rpl](#)], traffic that goes down does not generally go back up again, whereas P2P traffic within a DODAG might go up to a common parent and then down to the destination. In terms of instance relationship, this means that when an upwards and a downwards instances are bound together, traffic from the former may be transferred to the latter, but not the





### Figure 1: The DIO Base Object

Directional (D): The Directional (D) flag is set to indicate that the instance is intended for directional operation, and is reset otherwise. When the Directional (D) flag is set a value of 0 for the MOP field indicates upwards whereas any other value specified in [[I-D.ietf-roll-rpl](#)] indicates downwards. All other values of MOP shall be considered downwards unless explicitly specified otherwise.

## 6. Operations

This specification allows an organization of Instances as follows:

Instances MUST be organized as a Directed Acyclic Graph. This information MUST be commissioned into the devices so they know both which instances they should participate in, and which direction of transfer is allowed between instances.

A spanning instance using OF0 [[I-D.ietf-roll-of0](#)] MAY be used as root in that instance DAG.

This specification defines a new bit in the RPL [[I-D.ietf-roll-rpl](#)] DODAG Information Object (DIO) with the Directional (D) flag that indicates a directional operation for a given instance. An

implementation that does not support that new bit will not be able to propagate it.

In case of a directional operation,

The direction is indicated by the MOP field, a MOP set to a value 0 means upwards and any other setting indicates downwards.

Links are still REQUIRED to allow bidirectional operations

Only the metrics that correspond to the DAG direction are used for the parent selection.

An upward instance SHOULD install routes that lead to the root and beyond – typically the default route.

A downwards instance MAY ONLY install more specific routes that are injected by nodes in the DODAG through the DAO process.

P2P operations are achieved by associating a child upwards instance with a parent downwards instance.

A packet MUST NOT be transferred from a parent instance to a child instance.

A packet MAY be transferred from a child instance to its parent instance if and only if the child instance does not provide a route to the destination, or the parent instance provides a more specific route (longer match) to the destination.

Transferring from an upwards instance to a downwards instance is desirable for Point to Point communication within a RPL domain.

Other forms of transfer do not denote a classical operation of the protocol and as a general guidance they SHOULD be avoided. It is possible, though, that such transfer becomes useful in a controlled environment, for instance in the case of a transfer onto a last resort spanning instance. Policies MAY be put in place to override the general guidance and allow such transfers.

## 7. Backwards Compatibility

An OF is generally designed to compute a Rank of a directional link in a fashion that is different from a bidirectional link, and in particular will not use the same metrics and thus obtain different ranks for a same situation. For that reason, it is important that the OF is aware that an instance is supposed to define a directional



directional DODAGs are allowed in a directional instance.

It might happen that for some purposes like higher availability, an implementation that does not support directional links is administratively allowed to join a directional DODAG. In that case, the extension of the DODAG that starts at that device will not be directional, but the instance will still be functional.

In that case, it might also happen that a device that supports directional DODAGs per this specification sees candidate neighbors that expose the Directional flag and some others that do not. An OF that supports directional links SHOULD favor directional links over non directional links, in a fashion that is to be specified by the OF. In the case of OF0 [[I-D.ietf-roll-of0](#)], the 'D' flag should be accounted for before the computation of item 8 in the "Selection Of The Preferred Parent" [section 4.2.1](#), that is before ranks are calculated and can be compared.

## [8.](#) IANA Considerations

This specification requires that a bit in DIO shall be assigned to indicate directional link operations as specified in [Section 5](#)

## [9.](#) Security Considerations

Security considerations for this proposal are to be developed in accordance with recommendations laid out in, for example, [[I-D.tsao-roll-security-framework](#)].

## [10.](#) Acknowledgements

The author wishes to recognize Richard Kelsey, JP Vasseur, Tom Phinney, Robert Assimiti, Don Sturek, Thomas Clausen and Yoav Ben-Yehezkel for their various contributions.

## [11.](#) References

### [11.1.](#) Normative References

[[I-D.ietf-roll-rpl](#)]  
Winter, T., Thubert, P., Brandt, A., Clausen, T., Hui, J., Kelsey, R., Levis, P., Pister, K., Struik, R., and J. Vasseur, "RPL: IPv6 Routing Protocol for Low power and

Lossy Networks", [draft-ietf-roll-rpl-19](#) (work in progress), March 2011.

[I-D.ietf-roll-terminology]

Vasseur, J., "Terminology in Low power And Lossy Networks", [draft-ietf-roll-terminology-06](#) (work in progress), September 2011.

[RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", [BCP 14](#), [RFC 2119](#), March 1997.

## [11.2](#). Informative References

[I-D.ietf-roll-of0]

Thubert, P., "RPL Objective Function Zero", [draft-ietf-roll-of0-20](#) (work in progress), September 2011.

[I-D.tsao-roll-security-framework]

Tsao, T., Alexander, R., Daza, V., and A. Lozano, "A Security Framework for Routing over Low Power and Lossy Networks", [draft-tsao-roll-security-framework-02](#) (work in progress), March 2010.

[RFC5548] Dohler, M., Watteyne, T., Winter, T., and D. Barthel, "Routing Requirements for Urban Low-Power and Lossy Networks", [RFC 5548](#), May 2009.

[RFC5673] Pister, K., Thubert, P., Dwars, S., and T. Phinney, "Industrial Routing Requirements in Low-Power and Lossy Networks", [RFC 5673](#), October 2009.

[RFC5826] Brandt, A., Buron, J., and G. Porcu, "Home Automation Routing Requirements in Low-Power and Lossy Networks", [RFC 5826](#), April 2010.

[RFC5867] Martocci, J., De Mil, P., Riou, N., and W. Vermeylen, "Building Automation Routing Requirements in Low-Power and Lossy Networks", [RFC 5867](#), June 2010.

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