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**RPL Capabilities**  
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Abstract

This draft enables the discovery, advertisement and query of capabilities for RPL nodes.

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## [1.](#) Introduction

RPL [[RFC6550](#)] specifies a proactive distance-vector based routing scheme. The protocol creates a DAG-like structure which operates with a given "Mode of Operation" (MOP) determining the minimal and mandatory set of primitives to be supported by all the participating nodes.

This document adds a notion of capabilities using which nodes in the network could inform its peers about its additional capabilities. This document highlights the differences of capabilities from that of Mode of operation and explains the necessity of it.



### **1.1. Requirements Language and 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 [RFC 2119](#) [[RFC2119](#)].

MOP: Mode of Operation. Identifies the MOP of the RPL Instance as administratively provisioned at and distributed by the DODAG root.

MOPex: Extended MOP: As defined in [[I-D.ietf-roll-mopex](#)].

Capabilities: Additional features or capabilities that are supported by the node.

DAO: DODAG Advertisement Object. An RPL message used to advertise the target information in order to establish routing adjacencies.

DIO: DODAG Information Object. An RPL message initiated by the root and is used to advertise the network configuration information.

Current parent: Parent 6LR node before switching to the new path.

NPDAO: No-Path DAO. A DAO message which has target with lifetime 0.

Upstream path/direction: Path or direction from the node to the Root in a DAG.

Downstream path/direction: Path or direction to the node from the Root in a DAG.

This document uses terminology described in [[RFC6550](#)]. For the sake of readability all the known relevant terms are repeated in this section.

### **1.2. What are Capabilities?**

Currently RPL specification does not have a mechanism whereby a node can signal the set of features that are available on its end. Such a mechanism could help the root to advertise its capabilities and in response also determine some advanced information about the capabilities of the joining nodes. This document defines Capabilities which could be supported by the nodes and handshaked as part of RPL signaling. Capabilities are embedded as RPL control message option as defined [Section 6.7 of \[RFC6550\]](#) in the base messages of DIO, DAO and DAO-ACK signaling.



## **2. Requirements for this document**

Following are the requirements considered for this documents:

- REQ1: Backwards compatibility. The new options and new fields in the DIO message should be backward compatible i.e. if there are nodes which support old MOPs they could still operate in their own instances.
- REQ2: Optional capabilities handshake. Capabilities are features, possibly optional, which could be handshaked between the nodes and the root within an RPL Instance.
- REQ3: Capabilities handshake could be optionally added with existing MOPs. Capabilities been optional in nature could be put to use with existing MOPs. Capabilities and MOP-extension is mutually independent i.e. a DIO can have a capabilities option, MOP-extension option or both in the same message.
- REQ4: Capabilities could be explicitly queried.

### **2.1. How are Capabilities different from existing RPL primitives?**

The Mode of Operation (MOP) field in RPL mandates the operational requirement for the nodes joining as routers. MOP and DIO Configuration Option is strictly controlled by the Root node in RPL. Intermediate 6LRs cannot modify these fields. Also, the MOP never changes for the lifetime of the RPL Instance. Changes in DIO Configuration Option are possible but are rare. Capabilities, on the other hand, might change more dynamically.

RPL DIO message also carries routing metrics and constraints as specified in [\[RFC6551\]](#). Metrics and constraints are used as part of objective function which aids in node's rank calculation. A router may use capabilities carried in DIO message as additional metrics/constraints. However, capabilities have a larger scope and may be carried in other messages other than DIO and can flow in both the directions (upstream and downstream).

## **3. Capabilities**

Handling of Capabilities MUST be supported if the network uses MOPex [\[I-D.ietf-roll-mopex\]](#).

Note that capabilities and MOPex are mutually exclusive and it is possible for an implementation to support either or both of the options.



### 3.1. Capability Control Message Option

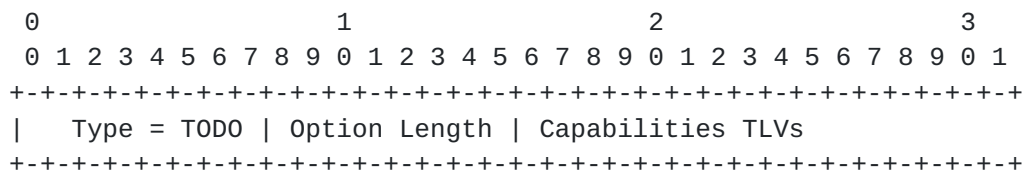


Figure 1: Capabilities Option

Multiple capabilities could be sent in the same message. The length field allows the message parser to skip the capability TLV parsing.

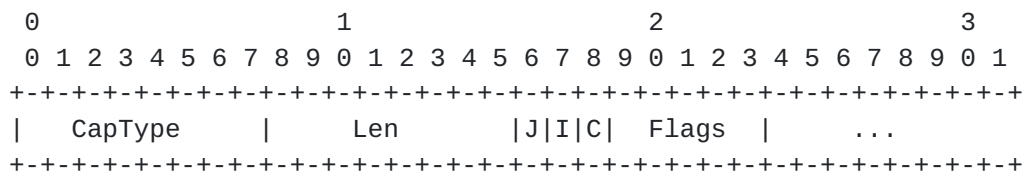


Figure 2: Capabilities TLV

Every capability is identified by its type and it may have an optional Capability Info. Note that a given capability may or may not be disseminated with additional information depending on the scope of the capability indicated by the I bit.

Len: 8-bit unsigned integer, representing the length in octets of the TLV, not including the CapType, Length and Flags fields.

J = Join only as leaf if capability not understood.

I = Ignore the message if this capability is not understood.

C = Flag indicating that the capability MUST be copied in the downstream message.

### 3.2. Capabilities Handshake

The root node could advertise the set of capabilities it supports in the DIO message. A node could take advantage of the knowledge that the root supports a particular capability. Similarly a node could advertise its capabilities in the DAO message using the capability control message option defined in this document. Capabilities advertised by non-root nodes are strictly a subset of the capabilities advertised by the root.





In storing MOP, the DAO message from the 6LR could contain multiple target options because of the DAO-Aggregation. The targets of the capabilities option are indicated by one or more Target options that precede the Capabilities Option. This handling is similar to the Transit Information Option as supported in [Section 6.7.8. of \[RFC6550\]](#).

#### **4. Guidelines for defining new capabilities**

This section provides guidelines/recommendations towards defining new capabilities. Note that the capabilities might be carried as part of the multicast messaging such as DIO and hence the set should be used in restrictive manner as far as possible.

##### **4.1. Handling Capability flags**

A node MUST drop or discard the message with an unknown capability with 'D' flag set. The message MUST be discarded silently.

The 'J' (join) flag can be set in context to a capability either by a 6LR or the root. The 'J' flag indicates that if the capability is not supported by a node then it can join the instance only as a 6LN (or do not join as 6LR).

The 'C' (copy) flag is set by the node indicating that the capabilities MUST be copied downstream by the node even if the node does not understand the capability.

##### **4.1.1. Rules to handle capabilities flag**

**On receiving a capability it does not support, the node MUST check the 'J' flag of the capability before joining the Instance. If the 'J' flag is set then it can only join as a 6LN.**

If the node is operating as 6LR and subsequently it receives a capability from its preferred parent which it does not understand with 'J' flag set, then the node has to switch itself to 6LN mode. During switching the node needs to inform its downstream peers of its changed status by sending a DIO with infinite rank as mentioned in [RFC6550](#). Alternatively, a node may decide to switch to another parent with compatible and known capabilities.

Capabilities are used to indicate a feature that is supported by the node. Capabilities are not meant for configuration management for e.g., setting a threshold.

#### **5. Node Capabilities**



## 5.1. Capability Indicators

Capability Indicators indicates the capabilities supported by the node in the form of simple flags. Capabilities who do not have additional information to be specified could make use of these flags to indicate their support.

### 5.1.1. Format of Capability Indicators

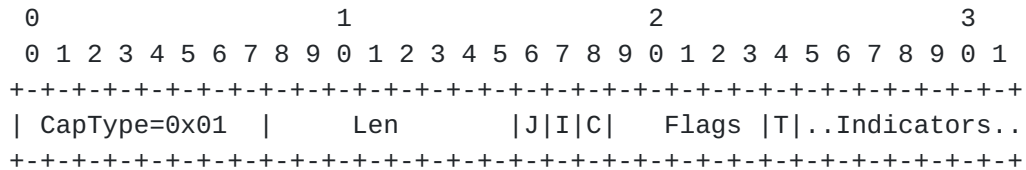


Figure 3: Capability Indicators TLV

Flags: LRs MUST set it to 0. I bit will always be set to 0.

T flag (Bit 1): Indicates whether the node supports 6LoRH [[RFC8138](#)].

## 5.2. Routing Resource Capability

Storing mode of operation requires each intermediate router in the LLN to maintain routing states' information in the routing table. LLN routers typically operate with constraints on processing power, memory, and energy (battery power). Memory limits the number of routing states an LR and BR can maintain. When the routing table of an LR or BR is full, it will either reject the new DAO messages received or will use some replacement policy to remove a routing entry and add the new one. Rejection of DAO messages will lead to an increase in DAO message transmission that impacts the energy and network convergence time. Routing state replacement leads to downward path downtime.

One possible way to solve problems due to routing table size constraint is to use this information to add neighbors to the DAO parent set. Routing resource capability can be used by LR and BR to advertise their current routing table usage details in the network. LR or LNs in LLN can use this information in the selection of the DAO parent set. PCE can use this information to select intermediate routers for the projected routes. Routing Resource is an optional capability.

Routing resource capability sent in DIO message has link local scope and it MUST not be forwarded. The 'C' bit of this capability MUST be set to 0.



### 5.2.1. Format of Routing Resource Capability

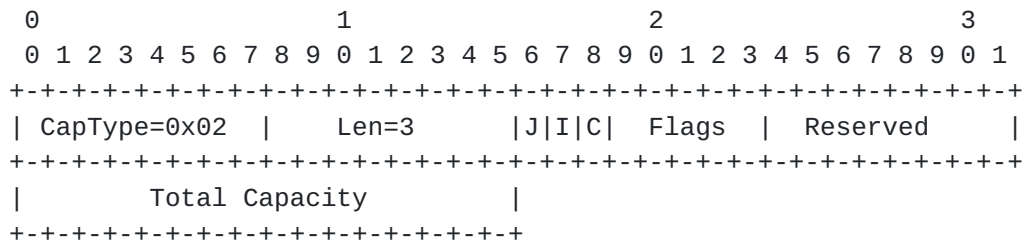


Figure 4: Routing Resource Capability TLV

Type: 0x02.

Flags: I bit MUST be set to 0. C bit MUST be set to 0.

Len: 8-bit unsigned integer, representing the length in octets of the option, not including the Option Type and Length/flags fields.

Resvd: 8-bit unused field. It MUST be initialized to zero by the sender and MUST be ignored by the receiver.

Total Capacity: 16 bit unsigned integer representing the routing table size.

## 6. Acknowledgements

Thanks to Georgios Papadopoulos, Li Zhao for early review and feedback.

## 7. IANA Considerations

### 7.1. New option: Capabilities

New entry is required for supporting new Capabilities option in the "RPL Control Message Options" space [[RFC6550](#)].

Value	Meaning	Reference
0x01	Capability Indicators	This document
0x02	Routing Resource Capability	This document

New options



### **7.2. New Registry for Capabilities Flags**

IANA is requested to create a registry for the Capabilities flags as described in [Section 2.1](#) of this document. This registry should be located in TODO. New Capabilities flags may be allocated only by an IETF review. Currently no flags are defined by this document. Each value is tracked with the following qualities:

- o Flag
- o Description
- o Defining RFC

### **7.3. New Registry for Capabilities Indicators**

IANA is requested to create a registry for the Capabilities Indicators as described in [Section 5.1](#) of this document. This registry should be located in TODO. New Capabilities indicators may be allocated only by an IETF review. Each value is tracked with the following qualities:

- o Flag
- o Description
- o Defining RFC

## **8. Security Considerations**

The options defined in this document are carried in the base message objects as defined in [\[RFC6550\]](#). The RPL control message options are protected by the same security mechanisms that protect the base messages.

Capabilities flag can reveal that the node has been upgraded or is running a old feature set. This document assumes that the base messages that carry these options are protected by RPL security mechanisms and thus are not visible to a malicious node.

[TODO] implications of malicious attack involving setting the capability flags.

## **9. References**





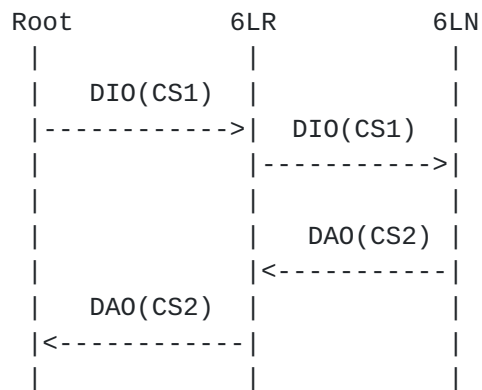
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**Appendix A. Capability Handshake Example**

CS: Capabilities Set

CS1: Capabilities set advertised by root

CS2: Capabilities set advertised by node. CS2 is a subset

of CS1.

Figure 5: Capabilities Option

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