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**Smart Route Request for Lightweight On-demand Ad hoc Distance-vector  
Routing - Next Generation  
draft-yi-loadngsmartrreq-02**

Abstract

This document describes the Smart Route Request extension for Lightweight Ad hoc On-Demand - Next Generation (LOADng) distance vector routing protocol. It allows making use of existed routing information to forward Route Request message, and helps reducing routing overhead in LOADng.

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## **1. Introduction**

Smart Route Request is an extension of LOADng protocol [[I-D.clausen-lln-loadng](#)] for use in forwarding Route Request message (RREQ), based on the routing information already known by the LOADng router.

In LOADng [[I-D.clausen-lln-loadng](#)], on receiving an RREQ message destined to other routers, an intermediate router has to multicast the RREQ message to all its neighbor routers. The Smart RREQ specified in this document makes use of available routing information in the local router, if possible, to reduce message multicasting. It does not require extract message exchange, and does not introduce computation overload.

Compared to RREQ dissemination by classical flooding, Smart RREQ can reduce up to 90% of route discovery overhead, depending on the scenarios applied.

## **2. Terminology**

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 [[RFC2119](#)].

This document uses the terminology and notation defined in [[I-D.clausen-lln-loadng](#)].

## **3. Applicability Statement**

This protocol:

- o Is an extension of LOADng for RREQ message forwarding.
- o Makes use of routes available in the local router, and forward the RREQ message in unicast to the desired destination, if possible.
- o Can reduce the overhead used for route discovery in LOADng, especially in the scenarios where the data packets are sent to a few concentrators in the network.
- o Can work seamlessly with LOADng protocol, even with the LOADng Routers without Smart RREQ extension.

**4. Problem Statement**

In route discovery of LOADng [[I-D.clausen-lln-loadng](#)], the protocol explicitly prohibits intermediate routers from replying RREQ messages. Only the destination is permitted to respond to an RREQ by unicasting a Route Reply (RREP) message. For example, as shown in Figure 1, in a LOADng network, Router A initiates a route discovery to Router D. Even the intermediate Routers (Router B and Router C in this case) have already available routes to Router D, they have to broadcast the RREQ message until the message reaches the final destination Router D. The Router D can then send an RREP to build the router from Router A to Router D.

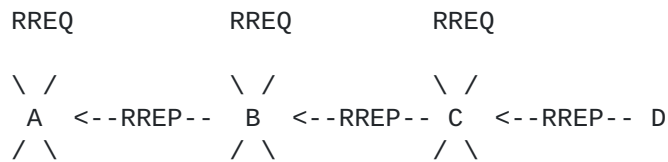


Figure 1: LOADng route discovery from Router A to Router D

Eliminating intermediate RREP can reduce the control message size and protocol complexity, but can also cause unnecessary multicast in the network. For example, in Figure 2, Router A initiates a route discovery to Router D. Router B, C and E have already routes to D. On receiving the RREQ, Router B, C and E still need to multicast the RREQ message to the whole network. The retransmission of the RREQ would be N (N is the number of routers in the network).

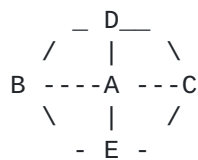


Figure 2: LOADng route discovery from Router A to Router D. Router B, C and E have already routes to Router D

In AODV [[RFC3561](#)], the intermediate routers can send reply to the originator of the router discovery. In the example of Figure 2, Router B, C and E will send an RREP to A directly, instead of flooding the RREQ message to the whole network. In this way, the RRE message can be kept "local" - but with the cost of complex sequence number check to avoid loops, and extra Gratuitous RREP message exchange.

The Smart Route Request described in this document reduces redundant multicast RREQ in LOADng if possible, while keeps the lightweight nature of LOADng.

**5. Protocol Signaling and Information Bases**

LOADng Smart Route Request is an extension of LOADng, and thus inherits all the information bases and signaling defined in [I-D.clausen-lln-loadng]. Only one additional flag for RREQ message is introduced:

RREQ.smart-rreq is a boolean flag which, when set ('1'), indicates the message is an RREQ\_SMART message, and MUST be processed according to this specification.

**6. Protocol Functioning**

This document concerns only RREQ dissemination of LOADng. When a LOADng Router initiates a route discovery, it floods an RREQ message with RREQ.smart-rreq flag set 1 (denoted RREQ\_SMART message).

On receiving the RREQ\_SMART message, the intermediate LOADng Router MUST process the message according to Section 12.2 of [I-D.clausen-lln-loadng]. Prior to the message being transmitted, the LOADng Router will check if there is an available Routing Tuple to the destination of RREQ\_SMART. If such Routing Tuple is found, the LOADng Router will unicast the RREQ\_SMART message to the R\_next\_addr of the Routing Tuple. Or else, the RREQ\_SMART message is transmitted according to the flooding operation specified for the network.

Figure 3 illustrates an example of operation of Smart Route Request. Router A requires a route discovery to Router D, and thus floods a RREQ\_SMART message. Router B and C has already available routes to Router D. They will unicast the RREQ\_SMART message to Router D.

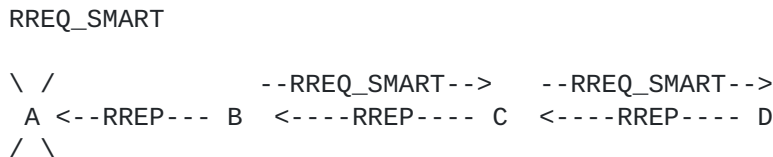


Figure 3: LOADng route discovery from Router A to Router D with Smart Route Request. Router B and Router C have already available routes to Router D

In the example in Figure 2, Router B, C and E will unicast the RREQ\_SMART to Router D. Although those RREQ\_SMART messages will not be processed by Router D because the messages carries longer routes, the RREQ\_SMART message is kept local, instead of being flooded to the whole network. This is not a rare case in real application, like all the Routers send data to a concentrator in the network.

If the Smart RREQ defined in this specification is used, the RREQ\_RETRIES parameter (defined in [[I-D.clausen-lln-loadng](#)]) MUST be great than 1. For a route discovery process, on the first RREQ message can be a RREQ\_SMART message. For the following retries, the RREQ.smart-rreq flag MUST be cleared ('0').

## **7. Smart Route Request Message**

The Smart Route Request Message (RREQ\_SMART) are generated by a LOADng Router for the first try, when it has a data packet to deliver to a destination, but the LOADng Router has no matching tuple in the Routing Set. The basic operation follows Section 12 of [[I-D.clausen-lln-loadng](#)], except the RREQ.smart-rreq flag is treated differently, as specified in this section.

### **7.1. RREQ\_SMART Generation**

A LOADng Router with Smart Route Request extension generate an RREQ\_SMART message for the first try of a route discovery process, with the following content:

- o RREQ.smart-rreq := TRUE;
- o All the other fields are set according to Section 12.1 of [[I-D.clausen-lln-loadng](#)].

If there was no RREP message received after  $2 * \text{NET\_TRAVERSAL\_TIME}$ , another RREQ message MUST be initiated. The following RREQ messages MUST set RREQ.smart-rreq to FALSE, and be treated as normal RREQ message as specified in Section 12 of [[I-D.clausen-lln-loadng](#)].

### **7.2. RREQ\_SMART Processing**

RREQ\_SMART messages are processed according to Section 12.2 of [[I-D.clausen-lln-loadng](#)].

### **7.3. RREQ\_SMART Forwarding**

The fields of an RREQ\_SMART message considered for forwarding MUST be updated following Section 12.3 of [[I-D.clausen-lln-loadng](#)], prior to

it being transmitted.

The RREQ\_SMART message is then transmitted, according to [Section 7.4](#).

#### **7.4. RREQ\_SMART Transmission**

RREQ\_SMART transmission is accomplished by the following procedure:

1. Find the Routing Tuple (henceforth, the "Matching Routing Tuple") in the Route Set, where:
  - \* R\_dest\_addr = RREQ.destination; and
  - \* R\_next\_addr does not equal to the interface address from which RREQ\_SMART was received.
2. If a Matching Routing Tuple is found, find the Local Interface Tuple (henceforth, matching Local Interface Tuple) in the Local Interface Set where:
  - \* I\_local\_iface\_addr\_list contains R\_local\_iface\_addr from the Matching Routing Tuple

The RREQ\_SMART is transmitted over the LOADng Interface, identified by the Matching Interface Tuple to the neighbor LOADng Router, identified by R\_next\_addr from the Matching Routing Tuple.

3. Otherwise, the RREQ\_SMART is transmitted according to [Section 12.4](#) of [[I-D.clausen-lln-loadng](#)].

### **8. Implementation Status**

This section records the status of known implementations of the protocol defined by this specification at the time of posting of this Internet-Draft, and based on a proposal described in [[RFC6982](#)]. The description of implementations in this section is intended to assist the IETF in its decision processes in progressing drafts to RFCs. Please note that the listing of any individual implementation here does not imply endorsement by the IETF. Furthermore, no effort has been spent to verify the information presented here that was supplied by IETF contributors. This is not intended as, and must not be construed to be, a catalog of available implementations or their features. Readers are advised to note that other implementations may exist.

According to [[RFC6982](#)], "this will allow reviewers and working groups

to assign due consideration to documents that have the benefit of running code, which may serve as evidence of valuable experimentation and feedback that have made the implemented protocols more mature. It is up to the individual working groups to use this information as they see fit".

There are currently one publicly-known implementation of smart route request extension of LOADng specified in this document.

### **8.1. Implementation of Ecole Polytechnique**

This implementation is developed by the Networking Group at Ecole Polytechnique and applied to LOADng [[I-D.clausen-lln-loadng](#)] for RREQ message forwarding. It can run over real network interfaces, and can also be integrated with the network simulator NS2. It is a Java implementation, and can be used on any platform that includes a Java virtual machine.

The implementation is based on -00 revision of this document, and includes about 20 line of additional code to the LOADng implementation. Simulation results based on NS2 have been published in [[IEEE\\_ICWITS2012](#)]. The results show that in point-to-point scenarios, Smart RREQ extension can save 30% RREQ flooding overhead compared to LOADng; in multipoint-to-point scenarios, Smart RREQ extension can save up to 90% RREQ flooding overhead compared to LOADng.

## **9. Security Considerations**

This Smart RREQ extension inherits the vulnerabilities of LOADng, as discussed in section 18 of [[I-D.clausen-lln-loadng](#)]. No additional vulnerability is introduced in this extension.

## **10. IANA Considerations**

IANA is requested to ....

## **11. References**

### **11.1. Normative References**

[I-D.clausen-lln-loadng]  
Clausen, T., Verdiere, A., Yi, J., Niktash, A., Igarashi, Y., Satoh, H., Herberg, U., Lavenu, C., Lys, T., and J. Dean, "The Lightweight On-demand Ad hoc Distance-vector



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- [RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", [BCP 14](#), [RFC 2119](#), March 1997.
- [RFC5444] Clausen, T., Dearlove, C., Dean, J., and C. Adjih, "Generalized Mobile Ad Hoc Network (MANET) Packet/Message Format", [RFC 5444](#), February 2009.

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- [IEEE\_ICWITS2012] Yi, J., Clausen, T., and A. Bas, "Smart Route Request for on-demand route discovery in constrained environments", Proceedings of IEEE ICWITS2012, IEEE International Conference on Wireless Information Technology and Systems, 2012.
- [RFC3561] Perkins, C., Belding-Royer, E., and S. Das, "Ad hoc On-Demand Distance Vector (AODV) Routing", [RFC 3561](#), July 2003.
- [RFC6982] Sheffer, Y. and A. Farrel, "Improving Awareness of Running Code: The Implementation Status Section", [RFC 6982](#), July 2013.

## **Appendix A. LOADng Smart Route Request Control Messages using [RFC5444](#)**

This section presents how the abstract LOADng Smart Route Request messages, used throughout this specification, are mapped into [RFC5444](#) messages. It only concerns the flag RREQ.smart-rreq.

### **A.1. RREQ\_SMART Messages Encoding Considerations**

This protocol makes use of RREQ message defined in [\[I-D.clausen-lln-loadng\]](#). Therefore, it reuses the RREQ Message Type defined in [\[I-D.clausen-lln-loadng\]](#), and defines one additional flags: RREQ.smart-rreq. Table 1 describes how the flag is mapped into [RFC5444](#).

RREQ Element	<a href="#">RFC5444</a> -Element	Considerations
RREQ.smart-rreq	FLAGS Message TLV	Encoded by way of a Message-Type-specific Message TLV of type FLAGS, defined in Table 3

Table 1: RREQ Message Elements for Smart Route Request

**Appendix B. [RFC5444](#)-Specific IANA Considerations**

This document only specifies one addition flag of RREQ, which has been allocated in "Message Types" namespace of [[RFC5444](#)], in [[I-D.clausen-lln-loadng](#)].

IANA is requested to add a RREQ Message-Type-specific Message TLV Type, in accordance with [Section 6.2.1 of \[RFC5444\]](#), with allocation policies as specified in Table 2.

Type	Description	Allocation Policy
129	FLAGS	
130-223	Unassigned	Expert Review

Table 2: RREQ Message-Type-specific TLV Type for LOADng-CT

Allocation of the FLAGS TLV from the RREQ Message-Type-specific Message TLV Types in Table 2 will create a new Type Extension registry, with type extension 0, as illustrated in Table 3.

Name	Type	Type Extension	Bit	Description
FLAGS	129	0	0	RREQ.smart-rreq flag (i.e., the RREQ message is a RREQ_SMART when it is set to 1)
FLAGS	129	1-255		Unassigned

Table 3: Message TLV Type assignment: FLAGS

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