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When to use RFC 6553, 6554 and IPv6-in-IPv6
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Abstract

This document states different cases where RFC 6553, RFC 6554 and IPv6-in-IPv6 encapsulation is required to set the bases to help defining the compression of RPL routing information in LLN environments.

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 March 17, 2016.

Table of Contents

1. Introduction

RPL [RFC6550] is a routing protocol for constrained networks. RFC 6553 [RFC6553] defines the "RPL option", carried within the IPv6 Hop-by-Hop header to quickly identify inconsistencies in the routing topology. RFC 6554 [RFC6554] defines the "RPL Source Route Header", an IPv6 Extension Header to deliver datagrams within a RPL routing domain.

Several discussions in the ROLL/6lo/6TiSCH Mailing Lists took place focusing in the definition of how to compress RPL Information in constrained environment. ROLL Virtual Interim Meeting (02-2015) concluded that there is a need to define how to use [RFC6553], [RFC6554] and IP-in-IP encapsulation to be able to set the correct environment for compression.

This document is going to be focused in data plane messages and how can be transmitted within the above mentioned RFCs.

2. Terminology and 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].

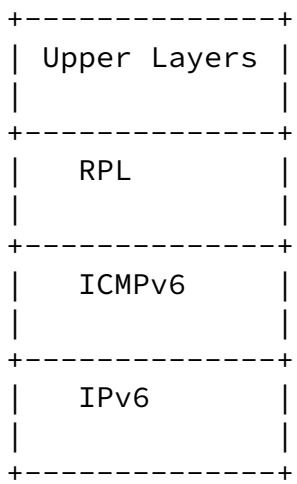
Terminology defined in [RFC7102]

3. Sample/reference topology

A RPL network is composed of a 6LBR (6LoWPAN Border Router), 6LR (6LoWPAN Router) and 6LN (6LoWPAN Node) as leaf logically organized in a DODAG structure (Destination Oriented Directed Acyclic Graph).

RPL defines the RPL Control messages (control plane), a new ICMPv6 message with Type 155. DIS, DIO and DAO messages are all RPL Control messages but with different Code values.

RPL supports two modes of Downward traffic: Storing, it is fully stateful or Non-Storing it is fully source routed. A RPL Instance is either fully storing or fully non-storing, i.e. a RPL Instance with a combination of storing and non-storing nodes is not supported with the current specifications.



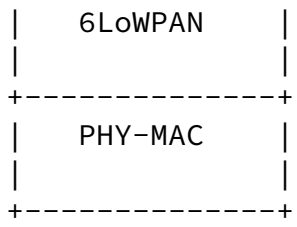


Figure 1: RPL Stack.

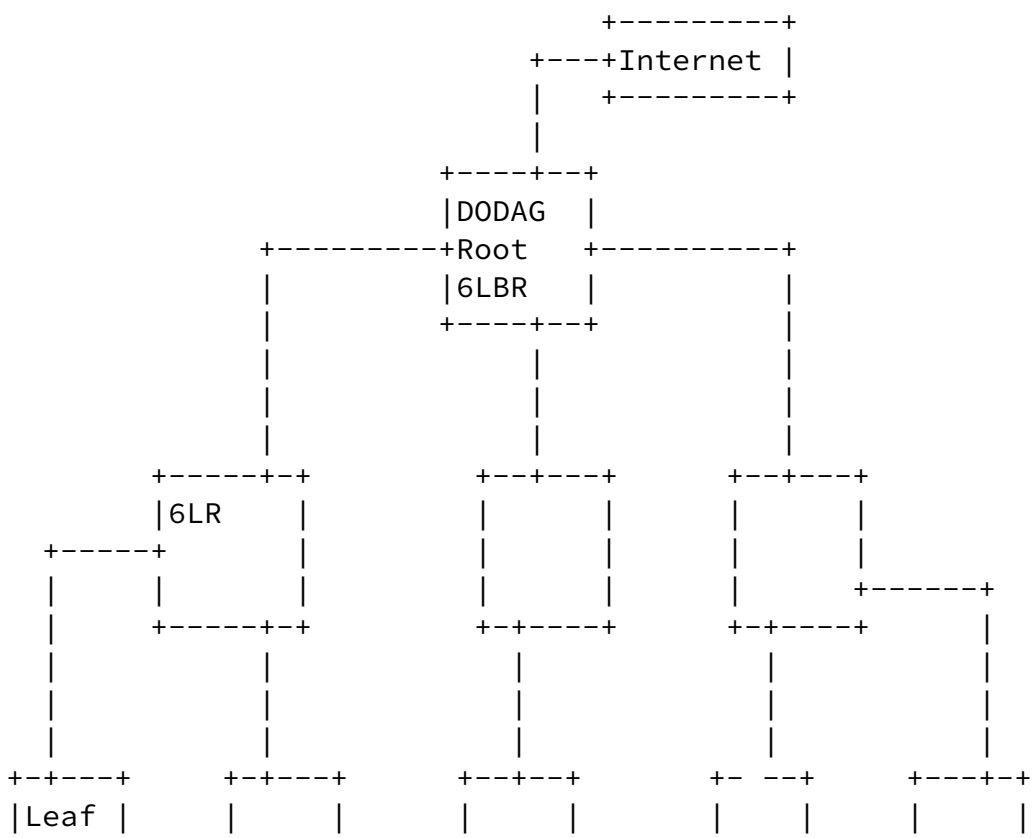


Figure 2: A reference RPL Topology.

4. Use cases

In data plane context a combination of RFC6553, RFC6554 and IP-in-IP encapsulation is going to be analyzed for the following traffic flows:

-Flow from RPL-aware-leaf to root

-Flow from root to RPL-aware-leaf

-Flow from not-RPL-aware-leaf to root

-Flow from root to not-RPL-aware-leaf

-Flow from RPL-aware-leaf to Internet

-Flow from Internet to RPL-aware-leaf

-Flow from not-RPL-aware-leaf to Internet

-Flow from Internet to not-RPL-aware-leaf

-Flow from RPL-aware-leaf to RPL-aware-leaf

-Flow from RPL-aware-leaf to not-RPL-aware-leaf

-Flow from not-RPL-aware-leaf to RPL-aware-leaf

-Flow from not-RPL-aware-leaf to not-RPL-aware-leaf

The applicability for Storing and Non-Storing (Non-S) modes for the previous cases is showed as follows:

Use Case	RPI (RFC 6553)	RH3 (RFC 6554)	IP-in-IP	Non-S RPI	Non-S RH3	Non-S IP-in-IP
RPL-aware-leaf to root	Yes	?	Yes	Yes	?	Yes

root to RPL-aware-leaf	?	?	Yes	?	?	Yes
not-RPL-aware-leaf to root	Yes	?	Yes	Yes	?	Yes
root to not-RPL-aware-leaf	?	?	Yes	?	?	Yes
RPL-aware-leaf to Internet	Yes	?	Yes	Yes	?	Yes
Internet to RPL-aware-leaf	?	?	?	?	?	?
not-RPL-aware-leaf to Internet	?	?	yes	?	?	Yes
Internet to not-RPL-aware-leaf	?	?	Yes	?	?	Yes
RPL-aware-leaf to RPL-aware-leaf	Yes	?	Yes	Yes	?	Yes
RPL-aware-leaf to not-RPL-aware-leaf	?	?	Yes	?	?	Yes
not-RPL-aware-leaf to RPL-aware-leaf	?	?	Yes	?	?	Yes
not-RPL-aware-leaf to not-RPL-aware-leaf	?	?	Yes	?	?	Yes

Table 1: Posibility to transmit in Storing or Non-Storing mode: RPI, RH3, IP-in-IP encapsulation

5. Storing mode

5.1. Example of Flow from RPL-aware-leaf to root

As states in Section 16.2 of [RFC6550] a leaf node does not generally issue DIO messages, a leaf node accepts DIO messages (In inconsistency a leaf node generates DIO with infinite rank, to fix

it). It may issue DAO and DIS messages though it generally ignores

DAO and DIS messages.

Related to RFC 6554 the Source Header route is added and removed by DODAG root. RFC 6554 was created to strictly send information between RPL routers in the same RPL routing domain.

In storing mode is suitable the use of RFC 6553 to send RPL Information through HBH field checking the routing table to find out where to send the message. It may include IP-in-IP encapsulation to transmit information not related with the RPL domain.

In this case the flow comprises:

RPL-aware-leaf (6LN) --> 6LR --> root (6LBR)

TODO: ADD explanation and picture based on the following table.

5.1.1. Summary of the use of headers

TODO: What about fragmentations headers?

Header	6LN	6LR	6LBR
Inserted headers	?	?	?
Removed headers	?	?	?
Re-added headers	?	?	?
Modified headers	?	?	?
Untouched headers	?	?	?

Storing: Summary of the use of headers from RPL-aware-leaf to root

5.2. Example of Flow from root to RPL-aware-leaf

In this case the flow comprises:

root (6LBR)--> 6LR --> RPL-aware-leaf (6LN)

TODO: ADD explanation and picture based on the following table

5.2.1. Summary of the use of headers

TODO: What about fragmentations headers?

Header	6LBR	6LR	6LN
Inserted headers	?	?	?
Removed headers	?	?	?
Re-added headers	?	?	?
Modified headers	?	?	?
Untouched headers	?	?	?

Storing: Summary of the use of headers from root to RPL-aware-leaf

5.3. Example of Flow from root to not-RPL-aware-leaf

In this case the flow comprises:

root (6LBR)--> 6LR --> not-RPL-aware-leaf (6LN)

TODO: ADD explanation and picture based on the following table

5.3.1. Summary of the use of headers

TODO: What about fragmentations headers?

Header	6LBR	6LR	not-RPL-aware 6LN
Inserted headers	?	?	?
Removed headers	?	?	?
Re-added headers	?	?	?
Modified headers	?	?	?
Untouched headers	?	?	?

Storing: Summary of the use of headers from root to not-RPL-aware-leaf

5.4. Example of Flow from not-RPL-aware-leaf to root

In this case the flow comprises:

not-RPL-aware-leaf (6LN) --> 6LR --> root (6LBR)

TODO: ADD explanation and picture based on the following table

5.4.1. Summary of the use of headers

TODO: What about fragmentations headers?

Header	not-RPL-aware 6LN	6LR	6LBR
Inserted headers	?	?	?
Removed headers	?	?	?
Re-added headers	?	?	?
Modified headers	?	?	?
Untouched headers	?	?	?

Storing: Summary of the use of headers from not-RPL-aware-leaf to root

5.5. Example of Flow from RPL-aware-leaf to Internet

RPL information from RFC 6553 should not go out to Internet. The router should take this information out before send the packet to Internet. The HBH Option is going to be analyzed in each node to the root.

In this case the flow comprises:

RPL-aware-leaf (6LN) --> 6LR --> root (6LBR) --> Internet

TODO: ADD explanation and picture based on the following table

5.5.1. Summary of the use of headers

TODO: What about fragmentations headers?

Header	6LN	6LR	6LBR	Internet
Inserted headers	?	?	?	?
Removed headers	?	?	?	?

Re-added headers	?	?	?	?
Modified headers	?	?	?	?
Untouched headers	?	?	?	?

Storing: Summary of the use of headers from RPL-aware-leaf to Internet

5.6. Example of Flow from Internet to RPL-aware-leaf

In this case the flow comprises:

Internet --> root (6LBR) --> 6LR --> RPL-aware-leaf (6LN)

TODO: ADD explanation and picture based on the following table

5.6.1. Summary of the use of headers

TODO: What about fragmentations headers?

Header	Internet	6LBR	6LR	6LN
Inserted headers	?	?	?	?
Removed headers	?	?	?	?
Re-added headers	?	?	?	?
Modified headers	?	?	?	?
Untouched headers	?	?	?	?

Storing: Summary of the use of headers from Internet to RPL-aware-leaf

5.7. Example of Flow from not-RPL-aware-leaf to Internet

In this case the flow comprises:

not-RPL-aware-leaf (6LN) --> 6LR --> root (6LBR) --> Internet

TODO: ADD explanation and picture based on the following table

5.7.1. Summary of the use of headers

TODO: What about fragmentations headers?

Header	not-RPL-aware 6LN	6LR	6LBR	Internet
Inserted headers	?	?	?	?
Removed headers	?	?	?	?
Re-added headers	?	?	?	?
Modified headers	?	?	?	?
Untouched headers	?	?	?	?

Storing: Summary of the use of headers from not-RPL-aware-leaf to Internet

5.8. Example of Flow from Internet to not-RPL-aware-leaf

In this case the flow comprises:

Internet --> root (6LBR) --> 6LR --> not-RPL-aware-leaf (6LN)

TODO: ADD explanation and picture based on the following table

5.8.1. Summary of the use of headers

Header	Internet	6LBR	6LR	not-RPL-aware 6LN

Header	6LN src	6LR	6LBR	6LN dst
Inserted headers	?	?	?	?
Removed headers	?	?	?	?
Re-added headers	?	?	?	?
Modified headers	?	?	?	?
Untouched headers	?	?	?	?

Storing: Summary of the use of headers from Internet to not-RPL-aware-leaf

5.9. Example of Flow from RPL-aware-leaf to RPL-aware-leaf

In [RFC6550] RPL allows a simple one-hop P2P optimization for both storing and non-storing networks. A node may send a P2P packet destined to a one-hop neighbor directly to that node. Section 9 in [RFC6550].

In this case the flow comprises:

6LN --> 6LR --> root (6LBR) --> 6LR --> 6LN

TODO: ADD explanation and picture based on the following table

5.9.1. Summary of the use of headers

Header	6LN src	6LR	6LBR	6LN dst
Inserted headers	?	?	?	?
Removed headers	?	?	?	?
Re-added headers	?	?	?	?
Modified headers	?	?	?	?
Untouched headers	?	?	?	?

Storing: Summary of the use of headers for RPL-aware-leaf to RPL-aware-leaf

5.10. Example of Flow from RPL-aware-leaf to not-RPL-aware-leaf

In this case the flow comprises:

6LN --> 6LR --> root (6LBR) --> 6LR --> not-RPL-aware 6LN

TODO: ADD explanation and picture based on the following table

5.10.1. Summary of the use of headers

Header	6LN	6LR	6LBR	not-RPL-aware 6LBR
Inserted headers	?	?	?	?
Removed headers	?	?	?	?
Re-added headers	?	?	?	?
Modified headers	?	?	?	?
Untouched headers	?	?	?	?

Storing: Summary of the use of headers from RPL-aware-leaf to not-RPL-aware-leaf

5.11. Example of Flow from not-RPL-aware-leaf to RPL-aware-leaf

In this case the flow comprises:

not-RPL-aware 6LN --> 6LR --> root (6LBR) --> 6LR --> 6LN

TODO: ADD explanation and picture based on the following table

5.11.1. Summary of the use of headers

Header	not-RPL-aware 6LBR	6LR	6LBR	6LN
Inserted headers	?	?	?	?
Removed headers	?	?	?	?
Re-added headers	?	?	?	?
Modified headers	?	?	?	?
Untouched headers	?	?	?	?

Storing: Summary of the use of headers from not-RPL-aware-leaf to RPL-aware-leaf

5.12. Example of Flow from not-RPL-aware-leaf to not-RPL-aware-leaf

In this case the flow comprises:

not-RPL-aware 6LN --> 6LR --> root (6LBR) --> 6LR --> not-RPL-aware 6LN

TODO: ADD explanation and picture based on the following table

5.12.1. Summary of the use of headers

Header	not-RPL-aware 6LN src	6LR	6LBR	not-RPL-aware 6LN dst
Inserted headers	?	?	?	?
Removed headers	?	?	?	?
Re-added headers	?	?	?	?
Modified headers	?	?	?	?
Untouched headers	?	?	?	?

Storing: Summary of the use of headers from not-RPL-aware-leaf to not-RPL-aware-leaf

6. Non Storing mode

6.1. Example of Flow from RPL-aware-leaf to root

In non-storing mode the leaf node uses Hop-By-Hop option (RFC 6553) to indicate the routing information to send messages to the DODAG root, this message is going to be analyzed in each node until arrive the DODAG root.

In this case the flow comprises:

RPL-aware-leaf (6LN) --> 6LR --> root (6LBR)

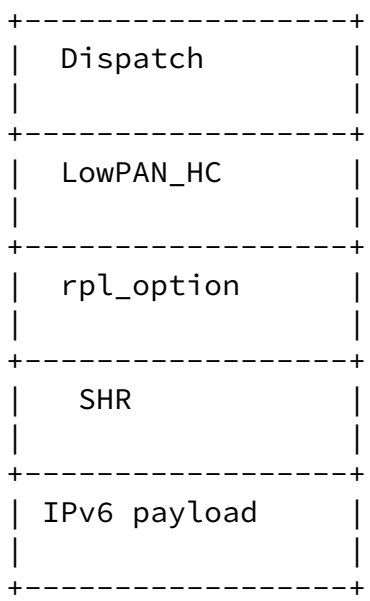


Figure 3: From leaf to Root - Non-Storing Mode

TODO: ADD explanation/fix picture based on the following table

6.1.1. Summary of the use of headers

Header	6LN	6LR	6LBR
Inserted headers	?	?	?
Removed headers	?	?	?
Re-added headers	?	?	?
Modified headers	?	?	?
Untouched headers	?	?	?

Storing: Summary of the use of headers from RPL-aware-leaf to root

6.2. Example of Flow from root to RPL-aware-leaf

In this case the flow comprises:

root (6LBR)--> 6LR --> RPL-aware-leaf (6LN)

TODO: ADD explanation and picture based on the following table

6.2.1. Summary of the use of headers

Header	6LBR	6LR	6LN
Inserted headers	?	?	?
Removed headers	?	?	?
Re-added headers	?	?	?
Modified headers	?	?	?
Untouched headers	?	?	?

Storing: Summary of the use of headers from root to RPL-aware-leaf

6.3. Example of Flow from root to not-RPL-aware-leaf

In this case the flow comprises:

root (6LBR)--> 6LR --> not-RPL-aware-leaf (6LN)

TODO: ADD explanation and picture based on the following table

6.3.1. Summary of the use of headers

Header	6LBR	6LR	not-RPL-aware 6LN
Inserted headers	?	?	?
Removed headers	?	?	?
Re-added headers	?	?	?
Modified headers	?	?	?
Untouched headers	?	?	?

Storing: Summary of the use of headers from root to not-RPL-aware-leaf

6.4. Example of Flow from not-RPL-aware-leaf to root

In this case the flow comprises:

not-RPL-aware-leaf (6LN) --> 6LR --> root (6LBR)

TODO: ADD explanation and picture based on the following table

6.4.1. Summary of the use of headers

Header	not-RPL-aware 6LN	6LR	6LBR
Inserted headers	?	?	?
Removed headers	?	?	?
Re-added headers	?	?	?
Modified headers	?	?	?
Untouched headers	?	?	?

Storing: Summary of the use of headers from not-RPL-aware-leaf to root

6.5. Example of Flow from RPL-aware-leaf to Internet

In this case the flow comprises:

RPL-aware-leaf (6LN) --> 6LR --> root (6LBR) --> Internet

TODO: ADD explanation and picture based on the following table

6.5.1. Summary of the use of headers

Header	6LN	6LR	6LBR	Internet
Inserted headers	?	?	?	?
Removed headers	?	?	?	?
Re-added headers	?	?	?	?
Modified headers	?	?	?	?
Untouched headers	?	?	?	?

Storing: Summary of the use of headers from RPL-aware-leaf to Internet

6.6. Example of Flow from Internet to RPL-aware-leaf

In this case the flow comprises:

Internet --> root (6LBR) --> 6LR --> RPL-aware-leaf (6LN)

TODO: ADD explanation and picture based on the following table

6.6.1. Summary of the use of headers

Header	Internet	6LBR	6LR	6LN
Inserted headers	?	?	?	?
Removed headers	?	?	?	?
Re-added headers	?	?	?	?
Modified headers	?	?	?	?
Untouched headers	?	?	?	?

Storing: Summary of the use of headers from Internet to RPL-aware-leaf				

6.7. Example of Flow from not-RPL-aware-leaf to Internet

In this case the flow comprises:

not-RPL-aware-leaf (6LN) --> 6LR --> root (6LBR) --> Internet

TODO: ADD explanation and picture based on the following table

6.7.1. Summary of the use of headers

Header	not-RPL-aware 6LN	6LR	6LBR	Internet
Inserted headers	?	?	?	?
Removed headers	?	?	?	?
Re-added headers	?	?	?	?
Modified headers	?	?	?	?
Untouched headers	?	?	?	?

Storing: Summary of the use of headers from not-RPL-aware-leaf to Internet

6.8. Example of Flow from Internet to not-RPL-aware-leaf

In this case the flow comprises:

Internet --> root (6LBR) --> 6LR --> not-RPL-aware-leaf (6LN)

TODO: ADD explanation and picture based on the following table

6.8.1. Summary of the use of headers

Header	Internet	6LBR	6LR	not-RPL-aware 6LN
Inserted headers	?	?	?	?
Removed headers	?	?	?	?
Re-added headers	?	?	?	?
Modified headers	?	?	?	?
Untouched headers	?	?	?	?

Storing: Summary of the use of headers from Internet to not-RPL-aware-leaf

6.9. Example of Flow from RPL-aware-leaf to RPL-aware-leaf

In this case the flow comprises:

6LN --> 6LR --> root (6LBR) --> 6LR --> 6LN

TODO: ADD explanation and picture based on the following table

6.9.1. Summary of the use of headers

Header	6LN src	6LR	6LBR	6LN dst
Inserted headers	?	?	?	?
Removed headers	?	?	?	?
Re-added headers	?	?	?	?
Modified headers	?	?	?	?
Untouched headers	?	?	?	?

Storing: Summary of the use of headers for RPL-aware-leaf to RPL-aware-leaf

6.10. Example of Flow from RPL-aware-leaf to not-RPL-aware-leaf

In this case the flow comprises:

6LN --> 6LR --> root (6LBR) --> 6LR --> not-RPL-aware 6LN

TODO: ADD explanation and picture based on the following table

6.10.1. Summary of the use of headers

Header	6LN	6LR	6LBR	not-RPL-aware 6LBR
Inserted headers	?	?	?	?
Removed headers	?	?	?	?
Re-added headers	?	?	?	?
Modified headers	?	?	?	?
Untouched headers	?	?	?	?

Storing: Summary of the use of headers from RPL-aware-leaf to not-RPL-aware-leaf

6.11. Example of Flow from not-RPL-aware-leaf to RPL-aware-leaf

In this case the flow comprises:

not-RPL-aware 6LN --> 6LR --> root (6LBR) --> 6LR --> 6LN

TODO: ADD explanation and picture based on the following table

6.11.1. Summary of the use of headers

Header	not-RPL-aware 6LBR	6LR	6LBR	6LN
Inserted headers	?	?	?	?
Removed headers	?	?	?	?
Re-added headers	?	?	?	?
Modified headers	?	?	?	?
Untouched headers	?	?	?	?

Storing: Summary of the use of headers from not-RPL-aware-leaf to RPL-aware-leaf

6.12. Example of Flow from not-RPL-aware-leaf to not-RPL-aware-leaf

In this case the flow comprises:

not-RPL-aware 6LN --> 6LR --> root (6LBR) --> 6LR --> not-RPL-aware 6LN

TODO: ADD explanation and picture based on the following table

6.12.1. Summary of the use of headers

Header	not-RPL-aware 6LN src	6LR	6LBR	not-RPL-aware 6LN dst
Inserted headers	?	?	?	?
Removed headers	?	?	?	?
Re-added headers	?	?	?	?
Modified headers	?	?	?	?
Untouched headers	?	?	?	?

Storing: Summary of the use of headers from not-RPL-aware-leaf to not-RPL-aware-leaf

7. IANA Considerations

There are no IANA considerations related to this document.

8. Security Considerations

TODO.

9. Acknowledgments

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To be completed with additional Acknowledgments.

10. References

10.1. Normative References

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10.2. Informative References

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