            OLSRv2 Backpressure Traffic Engineering Extension
                draft-szwabe-manet-backpressure-olsrv2-02

Abstract

   This document specifies a traffic engineering extension for OLSRv2
   based on backpressure, which allows advanced traffic shaping by
   providing each MANET router with information about packet queue
   levels of its neighbors.

Status of this Memo

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1. Introduction

This document specifies a traffic engineering extension for OLSRv2
[I-D.ietf-manet-olsrv2] based on backpressure, which can increase and
balance end-to-end throughput by providing each MANET router with
information about packet queue levels of its neighbors. This
document defines signaling and processing that is necessary, in
addition to the signaling and processing defined in
[I-D.ietf-manet-olsrv2], [RFC6130] and [RFC5444], to provide
efficient traffic engineering in OLSRv2 with a backpressure-based
scheme [SMN+10].

2. 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].

All terms introduced in [RFC5444], including "packet", "Packet
Header", "message", "Message Header", "Message Body", "Message Type",
"message sequence number", "hop limit", "hop count", "Address Block",
"TLV Block", "TLV", "Message TLV", "Address Block TLV", "type" (of
TLV), "type extension" (of TLV), "value" (of TLV), "address" and
"address object" are to be interpreted as described there.

All terms introduced in [RFC6130], including "interface", "MANET
interface", "network address", "link", "symmetric link", "1-hop
neighbor", "symmetric 1-hop neighbor", "symmetric 2-hop neighbor",
"constant", "interface parameter", "router parameter", "Information
Base", and "HELLO message" are to be interpreted as described there.

All terms introduced in [I-D.ietf-manet-olsrv2] and
[I-D.dearlove-olsrv2-metrics], including the terms "Router", "OLSRv2
interface", "Originator address", "Message originator address",
"Routing Set", "Routing Tuple" are to be interpreted as described
therein.

Additionally, this document uses the following terminology:

Flow
        A particular packet sequence transmitted through the
        network.

Flow Identifier
        A set of values which enable unambiguous identification of
        the Flow.

Timeslot
          A definite continuously repeating time period when events
          may occur. For example: "In a given Timeslot, 15 packets
          have been processed."

Scheduler
          In this document, a scheduler is considered as a part of
          the system maintaining the traffic on the router. A
          scheduler decides which Flow should be forwarded at a given
          time.

Queue Level
          The number of units (e.g., packets or bytes) in a Flow
          Queue on a router.

Backpressure
          The backpressure routing/scheduling policy is based on
          giving priority in forwarding to links and Flows that have
          higher backpressure, defined as the backlog differential
          (i.e., the difference between Queue Levels) at consecutive
          Routers.

Basic OLSRv2 Router
          A OLSRv2 Router without Backpressure Extension.

Backpressure Router
          A OLSRv2 Router featuring the Backpressure Extension.

Backpressure Interface
          A OLSRv2 interface running the Backpressure Extension.

Urgency
          Urgency is a queue-level-based scheduling weight used by a
          Backpressure Scheduler. Unless otherwise specified,
          urgency is defined as a backlog differential (i.e., the
          difference between Queue Levels) at consecutive Routers.

Router Urgency
          The maximum Urgency over all active Flows and all active
          connections on the router.

Backpressure Scheduler
          Specific type of scheduler which provides integrated packet
          scheduling and forwarding according to the backpressure
          policy based on the information on scheduling weights
          (Urgencies).

per-flow

This term refers to resources which may be regarded as allocated to a Flow.

[3](#). Applicability

The OLSRv2 extension specified in this document should be used together with an OLSRv2 multipath extension such as [I-D.multipath-olsrv2], in order to fully benefit from potential load balancing and throughput optimization. However, the extension specified in this document can be used without any other OLSRv2 extension, to increase end-to-end throughput.

Routers which do not support the OLSRv2 extension specified in this document are interoperable with routers that do support the extension according to the present specification.

[4](#). Protocol Overview

The OLSRv2 extension defined in the following sections provides traffic engineering capabilities to MANET routers, based on a backpressure scheme which can increase end-to-end throughput. This document specifies data flow identification, as well as periodical signaling of Queue Report (QR) and Urgency Report (UR) messages using the format specified in [RFC5444], which enables a router to monitor the queue levels of its neighbors.

QR and UR messages provide each node with the information enabling the backpressure max-weight scheduling. Information carried by QR messages is necessary for each router to calculate its backpressure-based scheduling weights (i.e., its urgencies), whereas UR messages are used to inform each router on urgencies within its neighborhood. By using QR and UR messages routers may perform backpressure max-weight scheduling, which is theoretically proven as a distributed load-balancing solution maximizing overall network throughput, e.g., enabling to avoid forwarding packets through a network bottleneck [SMN+10].

[5](#). Parameters and Constants

[5.1](#). Protocol and Port Numbers

The backpressure extension of OLSRv2 specifies QR and UR messages, which are included in packets as defined in [RFC5444]. These packets may be sent either by using the "manet" protocol number or the

"manet" UDP well-known port number, as specified in [RFC5498].

QR, UR and TC [I-D.ietf-manet-olsrv2], HELLO [RFC6130] messages
SHOULD be using the same transport protocol (either of IP or UDP) in
order to make it possible to combine messages of all these protocols
into a single [RFC5444] packet.

5.2. Multicast Address

The Backpressure Extension of OLSRv2 specifies QR and UR messages,
which are included in packets as defined by [RFC5444]. These packets
MAY be transmitted using the link local multicast address "LL-MANET-
Routers", as specified in [RFC5498].

5.3. Message Intervals

This specification defines the following message intervals:

QR_INTERVAL - the maximum time between transmission of two
   consecutive QR messages

UR_INTERVAL - the maximum time between transmission of two
   consecutive UR messages

Intervals defined in this document MUST comply to the following
constraints:

o UR_INTERVAL > 0

o UR_INTERVAL < QR_INTERVAL

5.4. Message Validity Times

This specification defines the following Advertised Information
Validity Times:

UR_HOLD_TIME - a validity time of UR message and a validity time of
   information carried by this message.

QR_HOLD_TIME - a validity time of QR message and a validity time of
   information carried by this message.

BP_HOLD_TIME - the maximum time without receiving a QR message or a
   UR message from a neighbor Router.

Validity times defined in this document MUST apply to the following
constrains:

   o UR_HOLD_TIME > UR_INTERVAL

   o QR_HOLD_TIME > QR_INTERVAL

   o BP_HOLD_TIME > UR_INTERVAL or BP_HOLD_TIME > QR_INTERVAL

   o In the case of high loss ratio of QR and UR messages, BP_HOLD_TIME
      should be made significantly greater than UR_INTERVAL or
      QR_INTERVAL interval.

5.5. Jitter

   If jitter, as defined in [RFC5148], is used, the following jitter
   parameters are required to be defined:

   QR_MAXJITTER - value of MAXJITTER used in [RFC5148] for periodically
      generated QR messages sent by this Router.

   UR_MAXJITTER - value of MAXJITTER used in [RFC5148] for periodically
      generated UR messages sent by this Router.

6. Information Bases

   The Information Bases defined here extend these specified in
   [RFC6130] and [I-D.ietf-manet-olsrv2] with both: information and its
   uses. This organization of information serve purpose of describing
   the Backpressure Extension, and DOES NOT constrain in any way
   implementation of this extension.

6.1. Local Information Base

   The Local Information Base is specified in [I-D.ietf-manet-olsrv2].
   Additionally information stored there is used for the Backpressure
   Extension signaling.

6.2. Interface Information Base

   The Interface Information Base is specified in
   [I-D.ietf-manet-olsrv2]. Additionally information stored there is
   used for the Backpressure Extension signaling.

6.3. Topology Information Base

   The Topology Information Base is specified in
   [I-D.ietf-manet-olsrv2]. Additionally information stored there is
   used for choosing on which interfaces QR and UR messages should be
   announced.

6.4. Received Message Information Base

The Received Message Information Base defined by
[I-D.ietf-manet-olsrv2] is extended by this specification by
introducing also an information about QR and UR messages. The
Received Message Information Base structure is not modified by the
Backpressure Extension. The way the messages are processed in
Information Base is defined in Section 7.

6.5. Flow Identification

In order to enable backpressure-based per-flow routing, unambiguous
Flow identification is specified by this document. For this purpose
Flow Identifier MAY hold the following parameters set:

o Destination address

o Source address

o Internet Protocol Number of a protocol used in the transport layer

o If used, an additional transport protocol source and destination
   address (i.e. port addresses in TCP or UDP)

This specification allows various combinations of these parameters to
be used in order to identify a Flow. Flow identification parameters
MUST be the same across the MANET network. Routers using different
set of parameters to identify the Flow are treated as Basic OLSRv2
Routers by Backpressure Routers.

One of the following parameters subsets MUST be used:

o Destination address, Source address, Internet Protocol Number with
   source and port addresses (if used).

o Destination address, Source address.

o Only destination address

Information about Flows is necessary from the perspective of the
Scheduler which differentiate the traffic depending on its type.
More detailed per-flow identification increases signaling overhead.
As the countermeasure, the Urgency signaling (see Section 7.2) which
significantly reduces amount of transmitted data is deployed.
Overhead of Urgency signaling itself does not increase with
complexity of Flow Identifier.

For encoding of Flow Identifier special QR Message-specific TLVs are

defined:

o PROTOCOL - Internet Protocol number used within transport layer.

o PORT - address used in transport layer, associated with a single
   address.

More detailed information about formatting of Flow Identifier in QR
Messages as specified in Section 7.1.2.

6.6. Queue Information Base

A Queue Information Base defined here stores information extracted
from received QR and UR messages. The Queue Information Base
consists of the Queue Level Set, the Urgency Set.

6.6.1. Queue Levels Set

The Queue Level Set contains neighbor's Queue Levels reported by
means of QR messages, as well as local Queue Levels of the
Backpressure Router. This set consists of Queue Level Tuples:

    (Q_addr, Q_fid, Q_level, Q_time)

where:

o Q_addr is the originator address of the Backpressure Router
   sending the QR message;

o Q_fid is a Flow Identifier;

o Q_level is a Queue Level reported for this Flow by the
   Backpressure Router;

o Q_time is the Tuple expiration time, after which Tuple MUST be
   removed.

6.6.2. Urgency Set

The Urgency Set records Urgency values. Urgency values are delivered
by means of UR messages (in the case of Urgencies of neighboring
Routers) or calculated using values from Queue Level Set (in the case
of local Urgency, i.e., the maximum Urgency of queues stored in the
local Router). This set consists of Urgency Tuples:

    (U_addr, U_level, U_time)

where:

o U_addr is the originator address of Backpressure Router associated
   with the Urgency value;

o U_level is an Urgency;

o U_time is a Tuple expiration time, after which Tuple MUST be
   removed.

6.6.3. Updating the Data

In order to maintain the Queue Information Base properly, the
following actions MUST be taken:

o An entry MUST be removed after the time defined as the Tuple
   expiration time (Q_time or U_time respectively).

o A new entry corresponding to a pair Q_addr and Q_fid in Queue
   Level Tuple or U_addr and U_level in Urgency Tuple, which is
   already present in the Queue Information Base, MUST be
   overwritten.

7. Signaling

Messages defined by [RFC6130] and [I-D.ietf-manet-olsrv2] are used as
specified there. This extension does not involve modifications to
these messages.

The packet and message format used by the Backpressure Extension of
OLSRv2 are defined in [RFC5444]. If not noted otherwise, options
defined in [RFC5444] MAY be used.

The QR and UR messages MUST follow specification of Message
Processing and Forwarding defined in [I-D.ietf-manet-olsrv2].

7.1. QR Message

7.1.1. QR Message Generation

QR messages are generated by a Router for each of its Backpressure
interfaces, and MUST be sent proactively and MAY be sent in a
combination of proactive and reactive techniques.

proactive - at a regular interval, known as QR_INTERVAL, which may
   be fixed or dynamic, and in case of fixed interval MAY be the same
   across the network.

   reactive - in reaction to a change of queue states, limited to
      queues that changed. In this case the maximum refresh time SHOULD
      be set, and minimal queue state change required to trigger QR
      message MUST be set (independently by each Router).

   A QR message MUST contain:

   o A <msg-hop-limit> := QR_HOPLIMIT, which limits the QR messaging
      network-wide overhead.

   o A message originator address, representing Router's originator
      address. A <msg-orig-addr> element MUST be used for this purpose.

   A QR message MAY contain:

   o Address blocks with associated PORT, PROTOCOL and QUEUE_LEVEL TLV
      as specified in [Section 7.1.2](), and as required for Flow
      Identification.

7.1.2. QR Message TLVs

7.1.2.1. Address Block TLVs

   In a QR message, a Router MAY include PROTOCOL Address Block TLV(s)
   as specified in Table 1.

Type	Value Length	Value
PROTOCOL	1 octet	Associated with a whole address block.

                      Table 1: PROTOCOL TLV definition

   In a QR message, a Router MAY include PORT Address Block TLV(s) as
   specified in Table 2.

Type	Value Length	Value
PORT	2 octets	Indicates that source or destination uses corresponding PORT value as port number.

                        Table 2: PORT TLV definition

   In a QR message, a Router MAY include QUEUE_LEVEL Address Block

TLV(s) as specified in Table 3.

```
+-------------+----------+-------------------------------------------+
|    Type     |  Value   |                  Value                    |
|             |  Length  |                                           |
+-------------+----------+-------------------------------------------+
| QUEUE_LEVEL |  up to 4 |    Queue Level expressed as unsigned       |
|             |  octets  | integer filed (encoded with network byte  |
|             |          |                 order).                   |
+-------------+----------+-------------------------------------------+
```

Table 3: QUEUE_LEVEL TLV definition

Relationship between PROTOCOL TLV, PORT TLV, QUEUE_LEVEL is based on
structure of Flow Identifier, and MUST comply with following rules:

o One entity of Flow Identifier with associated QUEUE_LEVEL TLV MAY
   be presented as addr_block and tlv_block pair.

o PORT TLV MUST not be used if there is no PROTOCOL TLV associated
   with these addresses.

o If required by Flow Identifier, one per address PORT TLV MAY be
   used.

o To be considered a valid Flow Identifier all used fields (PORT
   TLV, PROTOCOL TLV, QUEUE_LEVEL TLV) MUST be assigned to two
   addresses (representing source and destination address).

7.1.3. QR Message Transmission

In order to exchange the Queue Level values between Routers, Router
MUST generate QR Messages. The messages MUST be transmitted
according to QR_INTERVAL. The scheduler assigned to the Router MUST
provide sufficient information about Queue Levels of the Router. The
information about Queue Level of the sending Router MUST be the most
recent available. After each QR_INTERVAL, QR Message is generated
and then broadcast to Router's neighbors.

When a Router receives QR Message, an appropriate queue value is
assigned to message originator as according to the corresponding
entry in the Backpressure Information Base.

7.1.4. QR Message Processing

Each received (and not discarded) QR message, after initially being
processed according to [RFC5444], should be analyzed by Router and
used to update the Queue Information Base, according to the following

rules:

o There must be only one, the most actual, Queue Level Tuple in
   Queue Level Set of Queue Information Base corresponding to QR
   message originator address and Flow Identifier.

o If there is no Queue Level Tuple in Queue Level Set corresponding
   to information in QR message, such Queue Level Tuple MUST be
   created.

o If QR message contains Flow Identifier that is differently defined
   than the one used by this Router (see Section 6.5), the QR message
   MUST be discarded.

7.2. UR Message

7.2.1. UR Message Generation

UR messages are generated by a Router independently for each of
Routers Backpressure interfaces. UR messages SHOULD be sent
proactively, at a regular interval, called UR_INTERVAL, which may be
fixed or dynamic.

A UR message MUST contain:

o A <msg-hop-limit> := UR_HOP_LIMIT.

o A message originator address, representing router's originator
   address. A <msg-orig-addr> element MUST be used for this purpose.

o Routers Urgency value calculated from its Queue Information Base.
   Urgency value is calculated per interface, combining information
   from Routes Set from Topology Information Base and Queue
   Information Base.

o A unique identifier of the maximum Urgency holder together with
   its corresponding Urgency value. The maximum Urgency holder is a
   Neighbor Backpressure Router with the highest Urgency value of
   neighboring Routers in MANET network connected to particular
   Backpressure Interface. This information is acquired through
   combining Queue Information Base and Interface Information Base
   (of this particular Backpressure Interface).

A UR message MAY contain:

o A unique identifier of the maximum Urgency holder together with
   its corresponding Urgency value. This information is included in
   UR message if maximum Urgency holder urgency is greater or equal

to Interface Urgency. The maximum Urgency holder is a Neighbor
Backpressure Router with the highest Urgency value of neighboring
Routers in MANET network connected to particular Backpressure
Interface. This information is acquired through combining Queue
Information Base and Interface Information Base (of this
particular Backpressure Interface).

Both values of Backpressure interface's Urgency and Maximum Urgency
Holder are interface-specific. Thus UR messages are generated
independently.

7.2.1.1. Urgency calculation

This section presents only the example of a method for calculation of
Urgency value. Implementation of the Backpressure Extension can use
any other algorithm which will provide similar results.

Interface Urgency Holder is set as follows:

1. Interface Urgency := 0;

2. For each Queue Tuple (i) from Queue Set where Q_addr is in
    Originator Tuple from Originator Set of Local Information Base as
    O_orig_addr.

    * For each Routing Tuple from Routing Set where
       R_local_iface_addr = this interface.

       + For each Queue Tuple (j) from Queue Set where Q_addr (j) =
          R_next_iface_addr and Q_fid (j) = Q_fid (i).

          - If Interface Urgency < Q_value (j) - Q_value (i) then
             Interface Urgency := Q_value (j) - Q_value (i)

Maximum Urgency Holder (H_addr, H_urgency) for Backpressure Interface
is set as follows:

1. H_addr := Local interface address and H_urgency := Local
    interface Urgency

2. For each Urgency Tuple in Urgency Set of Queue Information Base:

    * If there is Link Tuple in Link Set of Interface Information
       Base, for which:

       + L_neighbor_iface_addr_list contains U_addr; AND

```
      +  L_status = HEARD.

      and U_level > H_urgency then:

      +  H_addr := U_addr;

      +  H_urgency := U_level.
```

7.2.2. UR Message TLVs

This specification defines one Message TLV and one Address Block TLV,
both specific for UR message.

7.2.2.1. Message TLVs

In a UR message, a Router MUST include one O_URGENCY TLV as specified
in Table 4.

Name	Value Length	Description
O_URGENCY	Up to 4 octets	Specifies the Urgency of the Originator Router. This value is represented as unsigned integer in network byte order.

Table 4: O_URGENCY TLV definition

7.2.2.2. Address Block TLVs

Name	Value Length	Description
URGENCY	Up to 4 octets	Specifies the Urgency of the Router. This value is represented as unsigned integer in network byte order.

Table 5: URGENCY TLV definition

7.2.3. UR Message Transmission

In order to exchange Urgency values between Routers, each Router MUST
generate UR Messages. The messages MUST be transmitted according to
UR_INTERVAL. Each Router utilizes its own Queue Information Base
which contains the most recent Urgency values among the defined

(2-hop by default) neighborhood. UR Message contains information
about Urgency of the Router which sends the message as well as the
information about the maximal Urgency (and its holder) in the sending
Router neighborhood (which in particular case may be the Router own
Urgency). After each UR_INTERVAL, UR Message has been generated and
broadcast to Router's neighbors.

To determine the maximal Urgency in the neighborhood, the latest
available information about Urgencies stored in Queue Information
Base is used.

7.2.4. UR Message Processing

Each received (and not discarded) UR message, after initially being
processed according to [RFC5444], is analyzed by the Router and used
to update the Queue Information Base, with the following rules in
mind:

o There must be only one Neighbor Tuple in Queue Information Base
   corresponding to the QR message originator address.

o If there is not Neighbor Tuple in Queue Information Base
   corresponding to the UR message originator address, such Neighbor
   Tuple MUST be created.

8. Data Available for Schedulers

The Backpressure Extension of OLSRv2 defines the minimal set of
features required to use backpressure-based schedulers. The network
area taken into account when the backpressure is calculated, SHOULD
NOT be considered as covering the full network.

In a case, when the values of QR_HOPLIMIT are set to proposed default
(1), the area where backpressure information is available is limited
to 2-hop neighborhood of the Router. Such range MAY be treated as an
approximation of a collision domain of the Router. A 1-hop
neighborhood area is covered by QR messages containing neighbors'
Queue Levels. This area is extended to 2 hops, thanks to application
of UR messages which contain information from the 2-hop neighborhood,
in the form of the maximum backpressure weight together with its
holders.

An agent of the standard OLSRv2 protocol interacts with the IP layer
through the Routing Set, consisting of the following information
(corresponding to Routing Tuples of OLSRv2):

o Destination address

o Next-hop address

o Interface address

o Distance

Backpressure Extension of OLSRv2 described in this document extends
this data in order to enable the scheduler to utilize the
backpressure weights. Unlike the standard OLSRv2, data available for
scheduler can be regarded as flow-oriented: each Flow has its own
queues. The routing possibilities MAY be determined for each Flow
separately.

The QR and UR messages are transmitted periodically in parallel with
regular data traffic. As a result, the Queue Level Set and Urgency
Set (described in Section 6.6) are updated. Based on this data the
scheduler is able to construct the table consisting of the following
elements:

o Flow Identifier (containing the destination Router address)

o Next-hop address

o Interface address

o Urgency

o Distance

which may be presented as follows:

| # | Flow | Next-hop | Interface | Urgency | Distance |
	Identifier	address	address		
1	(X)	(A)	eth0	4	2
2	(X)	(B)	eth0	10	3
3	(X)	(C)	eth0	9	2
4	(Y)	(C)	eth0	14	4
5	...	...	...	...	...

                Table 6: The table of extended routing entries

The Urgencies of the computing Router's Flows MAY be set on the basis
of the Queue Level Set entries. Following the classical backpressure

approach the Urgency for a given Flow and a given next-hop MAY be
calculated as the differences of the Flow queue levels on the
computing Router and the next-hop Router. Additionally, thanks to
the Urgency Set entries the scheduler is able to use the information
about the maximum value of Urgency in the neighborhood of the
computing node.

9. Interoperability with other OLSRv2 Routers

An OLSRv2 router running the backpressure extension can interoperate
with an OLSRv2 router that does not run this extension. The
Backpressure Extension provides functionalities considered as
auxiliary. Additional messages are implemented according to
[RFC5444] specification. Router which does not support the proposed
OLSRv2 protocol extension may simply discard additional information.

As for Backpressure Routers, the Router behavior for a case when
there is no information about Queue Levels available from Basic
OLSRv2 Routers is specified in Section 7.1.4. Same rules apply to
Backpressure Routers using different Flow identification (see
Section 6.5). The Backpressure Router can use following strategies
to effectively use routes of Basic OLSRv2 Routers:

o Temporary assuming Basic OLSRv2 Router's Queue Levels, that will
   make it last candidate for sending to.

o Temporary assuming that Basic OLSRv2 Router's Queue Level is
   average of Neighbor Backpressure Routers Queue Level for
   particular Flow.

10. Values for Parameters and Constants

10.1. Message Interval Parameters

o QR_INTERVAL := 300 milliseconds

o UR_INTERVAL := QR_INTERVAL / 8

10.2. Message Validity Times Parameters

o UR_HOLD_TIME := UR_INTERVAL x 3

o QR_HOLD_TIME := QR_INTERVAL x 3

10.3. Hop Limit Parameter

   o QR_HOPLIMIT := 1

   o UR_HOPLIMIT := QR_HOPLIMIT

10.4. Jitter Time Parameters

   o QR_MAXJITTER := QR_INTERVAL / 4

   o UR_MAXJITTER := UR_INTERVAL / 4

11. Security Considerations

   To be elaborated.

12. IANA Considerations

   This specification defines two Message Types, which must be allocated
   from the "Message Types" registry of [RFC5444].

12.1. Expert Review: Evaluation Guidelines

   For the registries where an Expert Review is required, the designated
   expert SHOULD take the same general recommendations into
   consideration as are specified by [RFC5444].

12.2. Message Types

   This specification defines two Message Types, to be allocated from
   the 0-223 range of the "Message Types" namespace defined in
   [RFC5444], as specified in Table 7.

                   +------+-------------------------+
                   | Type | Description |
                   +------+-------------------------+
                   | TBD1 | UR : Urgency report |
                   | TBD2 | QR : Queue Level report |
                   +------+-------------------------+

                    Table 7: Message Type assignment

12.3. Message-Type-specific TLV Type Registries

IANA is requested to create a registry for Message-Type-specific
Message TLVs for UR messages, in accordance with Section 6.2.1 of
[RFC5444], and with initial assignments and allocation policies as
specified in Table 8.

Name	Type	Description	Allocation Policy
O_URGENCY	128	Specifies Router's Urgency.	
	129-223	Unassigned	Expert Review

Table 8: UR Message-Type-specific Message TLVs

IANA is requested to create a registry for Message-Type-specific
Address block TLVs for UR messages, in accordance with Section 6.2.1
of [RFC5444], and with initial assignments and allocation policies as
specified in Table 9.

Name	Type	Description	Allocation Policy
URGENCY	128	Specifies Urgency of associated Router.	
	129-223	Unassigned	Expert Review

Table 9: UR Message-Type-specific Address block TLVs

IANA is requested to create a registry for Message-Type-specific
Message TLVs for QR messages, in accordance with Section 6.2.1 of
[RFC5444], and with initial assignments and allocation policies as
specified in Table 10.

Type	Description	Allocation Policy
128-223	Unassigned	Expert Review

Table 10: QR Message-Type-specific Message TLVs

IANA is requested to create a registry for Message-Type-specific

Address block TLVs for UR messages, in accordance with Section 6.2.1 of [RFC5444], and with initial assignments and allocation policies as specified in Table 11.

Name	Type	Description	Allocation Policy
PROTOCOL	128	Specifies Protocol Number used on the transport layer.	
QUEUE_LEVEL	129	Specifies Queue Level status.	
PORT	130	Specifies port address used on the transport layer.	
	131-223	Unassigned	Expert Review

Table 11: QR Message-Type-specific Address block TLVs

13. Acknowledgements

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Appendix A. Illustrations

A.1. QR Message Examples

   This appendix illustrates QR message examples. As QR message is a
   instance of [RFC5444] and its exact form depends on conveyed
   information formatted by the sender. Because of that following
   examples show only possible form that specified information can be
   presented.

   First example of QR message conveys information about Queue Levels of

two Flows. The Backpressure Router uses complex Flow Identifier
containing:

o Destination address

o Source address

o Internet Protocol Number of a protocol used in the transport layer

o If used, an additional transport protocol source and destination
   address (i.e. port addresses in TCP or UDP)

This message contains two information about Flows:

o UDP (17) stream from IP 192.168.40.1:4563 to 192.168.40.67:8213

o ICMP (1) ping requests from 192.168.40.72 to 192.168.40.69

```
       0                   1                   2                   3
       0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
      +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
      |      QR       |1 1 0 1|0 0 1 1|0 0 0 0 0 0 0 0 0 0 1 1 1 1 0 1|
      +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
      |                     Originator Address                        |
      +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
      |0 0 0 0 0 0 1|   Message Sequence Number    |0 0 0 0 0 0 0 0|
      +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
      |0 0 0 0 0 0 0 0|0 0 0 0 0 0 1 0|1 0 0 0 0| Rsv |0 0 0 0 0 0 1 1|
      +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
      |              Head (192.168.40.)              |    Mid (.1)   |
      +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
      |   Mid (.67)   |0 0 0 0 0 0 0 0|0 0 0 1 0 0 0 1|   PORT TLV    |
      +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
      |0 0 0 1 0 1|Rsv|0 0 0 0 0 1 0 0|  VALUE = UDP SRC PORT (4563)  |
      +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
      |  VALUE = UDP DST PORT (8213)  |  PROTOCOL TLV |0 0 0 1 0 0|Rsv|
      +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
      |0 0 0 0 0 0 0 1|  VALUE = 17   |QUEUE_LEVEL TLV|0 0 0 1 0 0|Rsv|
      +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
      |0 0 0 0 0 0 1 1|             VALUE  = QUEUE LEVEL              |
      +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
      |0 0 0 0 0 0 1 0|1 0 0 0 0| Rsv |0 0 0 0 0 0 1 1|     Head      |
      +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
      | Head (cont, 192.168.40.)     |   Mid (.72)   |   Mid (.69)   |
      +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
      |0 0 0 0 0 0 0 0|0 0 0 0 1 1 0 1|  PROTOCOL TLV |0 0 0 1 0 0|Rsv|
      +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
      |0 0 0 0 0 0 0 1|   VALUE = 1   |QUEUE_LEVEL TLV|0 0 0 1 0 0|Rsv|
      +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
      |0 0 0 0 0 1 0 0|             VALUE = QUEUE LEVEL              |
      +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
      | VALUE (cont)  |
      +-+-+-+-+-+-+-+-+-+
```

        Figure 1: QR Message example of two Flows with a full Flow
                             Identifier.

   Second example of QR message conveys information about Queue Levels
   of two Flows. Origin Backpressure Router uses Flow Identifier
   containing only:

   o Destination address

   o Source address

   This message contains two information about Flows:

o IP packets from IP 192.168.40.1 to 192.168.40.67

o IP packets from 192.168.40.72 to 192.168.40.69

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|     QR        |1 1 0 1|0 0 1 1|0 0 0 0 0 0 0 0 0 0 1 0 1 1 1 1|
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                      Originator Address                      |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|0 0 0 0 0 0 1|   Message Sequence Number    |0 0 0 0 0 0 0 0|
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|0 0 0 0 0 0 0 0|0 0 0 0 0 0 1 0|1 0 0 0 0| Rsv |0 0 0 0 0 0 1 1|
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|            Head (192.168.40.)            |    Mid (.1)    |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|   Mid (.67)   |0 0 0 0 0 0 0 0|0 0 0 1 0 0 1 0|QUEUE_LEVEL TLV|
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|0 0 0 1 0 0|Rsv|0 0 0 0 0 1 0 0|    VALUE = QUEUE LEVEL        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|         VALUE (cont)         |0 0 0 0 0 0 1 0|1 0 0 0 0| Rsv |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|0 0 0 0 0 0 1 1|             Head (192.168.40.)               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|  Mid (.72)    |   Mid (.69)   |0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0|
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|QUEUE_LEVEL TLV|0 0 0 1 0 0|Rsv|0 0 0 0 0 1 0 0|     VALUE      |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|          VALUE (cont) = QUEUE LEVEL          |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```
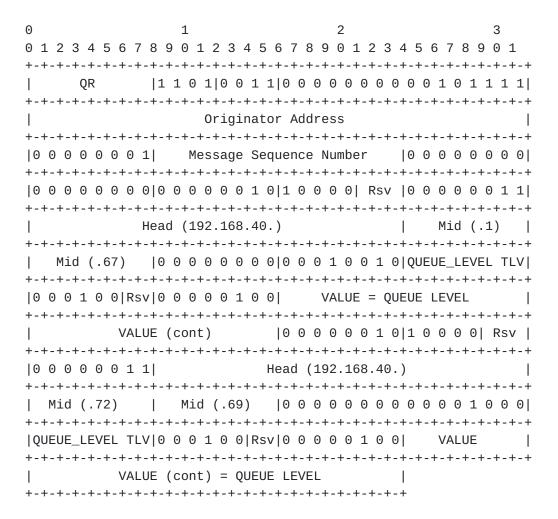
Figure 2: QR Message example of two Flows with a simplified Flow
                            Identifier.

A.2. UR Message Example

```
     0                   1                   2                   3
     0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     |     UR       |1 1 0 1|0 0 1 1|0 0 0 0 0 0 0 0 0 0 1 0 0 0 1 0|
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     |                    Originator Address                        |
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     |   Hop Limit   |   Message Sequence Number     |0 0 0 0 0 0 0 0|
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     |0 0 0 0 0 1 1 0| O_URGENCY TLV |0 0 0 1 0 0|Rsv|0 0 0 0 0 1 0 0|
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     |               VALUE = ORIGIN URGENCY LEVEL                   |
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     |0 0 0 0 0 0 0 1|0 0 0 0 0| Rsv |            Mid               |
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     |          Mid (cont)         |0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0|
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     |  URGENCY TLV  |0 0 0 1 0 0|Rsv|    VALUE = URGENCY LEVEL     |
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     |         VALUE (cont)        |
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 3: QR Message Example of one Flow.

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