A YANG model for Multicast Protocol for Low power and lossy Networks (MPL)
draft-ietf-roll-mpl-yang-02

Abstract

This document defines a YANG data model for management of Multicast Protocol for Low power and lossy Networks (MPL) implementations. The data model includes configuration data and state data.

Note

Discussion and suggestions for improvement are requested, and should be sent to roll@ietf.org.

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1. Introduction

This document defines a YANG [RFC7950] data model for management of Multicast Protocol for Low power and lossy Networks (MPL) [RFC7731] implementations. The data model covers configuration of MPL parameters per interface. It also provides information about which Multicast addresses are operationally used, and the seeds of the forwarded packets.

1.1. 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 [RFC2119].
The following terms are defined in [RFC6241] and are not redefined here:

- client
- configuration data
- server
- state data

The following terms are defined in [RFC7950] and are not redefined here:

- data model
- data node

The terminology for describing YANG data models is found in [RFC7950].

Terms like message, domain, seed, I, k, c are defined in [RFC7731].

Terms like YANG Schema Item iDentifier (SID) and delta are defined in [I-D.ietf-core-sid].

Multiple copies of a message can be received or sent by a node.

1.1.1. Tree Diagrams

YANG tree diagrams provide a concise representation of a YANG module, and SHOULD be included to help readers understand YANG module structure. Guidelines on tree diagrams can be found in Section 3 of [I-D.ietf-netmod-yang-tree-diagrams]. Tree diagrams used in this document follow the notation defined in [RFC8340].

2. MPL model

This document defines the YANG modules "ietf-yang-mpl-xxx", which specify a data model for MPL servers. The model is separated into four modules which can be loaded independently to accommodate the storage space to the wanted functionality. The model consists of the following parts: (1) "mpl-domain", (2) "mpl-op", (3) "mpl-seeds", and (4) "mpl-statistics". The four models are discussed below accompanied by their trees.
2.1. NMDA considerations

The Network Management Data Architecture (NMDA) is specified in [RFC8342]. The MPL protocol is designed for low-resource nodes, where the hardware is fixed once and for all. The configuration of the node in the MPL context is limited to enabling the interface(s) with Multicast addresses. The interface configuration of the YANG module replaces the multicast address assignment of section 2.6.2 of [RFC7390].

Consequently, the contents of the "candidate", "startup", "running", and "intended" datastores are identical. The conceptual datastore consists of an "operational" and an "intended" datastore. The "intended" store contains the nodes of the modules: ietf-yang-mpl-domain, and ietf-yang-mpl-ops. The "running" store contains the nodes of the modules: ietf-yang-mpl-seeds, and ietf-yang-mpl-statistics. The ietf-yang-mpl-domain is necessary when any MPL management is wanted. The two modules of the "running" store need the two modules of the "intended" store, and can be loaded dependent on the management wishes and resource constraints.

The modules ietf-yang-mpl-ops, ietf-yang-mpl-seeds, and ietf-yang-mpl-statistics "augment" ietf-yang-mpl-domain.

2.2. MPL-domain tree

The "mpl-domain" module describes the MPL-domains and associated Multicast addresses and the interfaces on which the Multicast addresses are enabled. The model allow for a short single MPL-domain configuration or a multi-domain configuration that needs more storage space.

module: ietf-yang-mpl-domain
    +--rw domain
        +--rw (multiple)?
        +--:(mpl-domain)
            +--rw mpl-domain
                +--rw domains* [domainID]
                    +--rw domainID  uint16
                    +--rw MClist*  inet:ipv6-address
                +--rw addresses* [MCaddress]
                    +--rw MCaddress  inet:ipv6-address
                    +--rw interfaces*  string
            +--:(mpl-single)
                +--rw mpl-single
                    +--rw MCaddresses*  inet:ipv6-address
2.3. MPL-ops tree

The generator node of a MPL message is called a seed that emits on a multicast address of a domain. The "mpl-ops" module describes the operational parameters settings per domain. The parameters determine the dynamics of the message reception intervals per domain [RFC7731].

module: ietf-yang-mpl-ops
   augment /mpl:domain:
      +--rw mpl-ops
         +--rw PROACTIVE_FORWARDING?    boolean
         +--rw SEED_SET_ENTRY_LIFETIME?  uint64
         +--rw mpl-parameter* [domainID]
            +--rw domainID          uint16
            +--rw DATA_MESSAGE_IMIN?  uint16
            +--rw DATA_MESSAGE_IMAX?  uint16
            +--rw DATA_MESSAGE_K?    uint16
            +--rw DATA_MESSAGE_TIMER_EXPIRATIONS? uint16
            +--rw CONTROL_MESSAGE_IMIN? uint16
            +--rw CONTROL_MESSAGE_IMAX? uint16
            +--rw CONTROL_MESSAGE_K?  uint16
            +--rw CONTROL_MESSAGE_TIMER_EXPIRATIONS? uint16

2.4. MPL-seeds tree

The "mpl-seeds" part describes the MPL buffer contents and the Trickle timer values associated with each seed and domain. Multiple seeds per domain may exist. The module exposes the state of the MPL buffer and key information about the messages in the MPL buffers at a given acquisition moment.
module: ietf-yang-mpl-seeds
augment /mpl:domain:
  +--rw SE_LIFETIME?  uint16
  +--ro mpl-seeds* [seedID domainID]
    +--ro seedID     uint64
    +--ro domainID   uint16
    +--ro local?     boolean
    +--ro generate-seqno?  uint8
    +--ro life-time?    uint64
    +--ro min-seqno?    uint8
    +--ro data-number?  uint8
    +--ro control-number?  uint8
    +--ro buffered-messages* [seqno]
      +--ro seqno    uint8
      +--ro I?       uint8
      +--ro c?       uint8
      +--ro e?       uint8
      +--ro t?       uint8

2.5. MPL-statistics tree

The "mpl-statistics" module describes the number of lost and correctly forwarded messages and its copies.

module: ietf-yang-mpl-statistics
augment /mpl:domain:
  +--ro mpl-statistics* [seedID domainID]
    | +--ro seedID     uint64
    | +--ro domainID   uint16
    | +--ro c-too-high? uint64
    | +--ro nr-forwarded?  uint64
    | +--ro nr-of-messages-received?  uint64
    | +--ro nr-of-messages-forwarded?  uint64
    | +--ro nr-of-copies-received?  uint64
    | +--ro nr-of-copies-forwarded?  uint64
    | +--ro nr-of-refused-copies?  uint64
    | +--ro nr-of-missed-messages?  uint64
    | +--ro nr-of-notreceived-messages?  uint64
    | +--ro nr-of-inconsistent-data?  uint64
    | +--ro nr-of-consistent-data?  uint64
    | +--ro nr-of-consistent-control?  uint64
    | +--ro statistics-interval?  uint64
    | +--x reset-buffer-statistics
  +--x reset-all-statistics
3. SID file generation

YANG Schema Item iDentifiers (SID) are allocated to replace the relatively long YANG identifiers by the much shorter SIDs. Consequently, the payload size is considerably reduced. The assignment tool is https://comi.space/. SIDs are allocated to the identifiers specified in the four modules. Their values are:

3.1. mpl-domain

<table>
<thead>
<tr>
<th>SID</th>
<th>Namespace</th>
<th>YANG identifier</th>
</tr>
</thead>
<tbody>
<tr>
<td>1004000</td>
<td>module</td>
<td>ietf-yang-mpl-domain</td>
</tr>
<tr>
<td>1004001</td>
<td>data</td>
<td>/ietf-yang-mpl-domain:domain</td>
</tr>
<tr>
<td>1004002</td>
<td>data</td>
<td>/ietf-yang-mpl-domain:domain/mpl-domain</td>
</tr>
<tr>
<td>1004003</td>
<td>data</td>
<td>/ietf-yang-mpl-domain:domain/mpl-domain /addresses</td>
</tr>
<tr>
<td>1004004</td>
<td>data</td>
<td>/ietf-yang-mpl-domain:domain/mpl-domain /addresses/MCaddress</td>
</tr>
<tr>
<td>1004005</td>
<td>data</td>
<td>/ietf-yang-mpl-domain:domain/mpl-domain /addresses/interfaces</td>
</tr>
<tr>
<td>1004006</td>
<td>data</td>
<td>/ietf-yang-mpl-domain:domain/mpl-domain /domains</td>
</tr>
<tr>
<td>1004007</td>
<td>data</td>
<td>/ietf-yang-mpl-domain:domain/mpl-domain /domains/MClist</td>
</tr>
<tr>
<td>1004008</td>
<td>data</td>
<td>/ietf-yang-mpl-domain:domain/mpl-domain /domains/domainID</td>
</tr>
<tr>
<td>1004009</td>
<td>data</td>
<td>/ietf-yang-mpl-domain:domain/mpl-single</td>
</tr>
<tr>
<td>1004010</td>
<td>data</td>
<td>/ietf-yang-mpl-domain:domain/mpl-single /MCaddresses</td>
</tr>
</tbody>
</table>

3.2. mpl-ops
Module : ietf-yang-mpl-ops
Revision : 2018-07-06

SID   Namespace       YANG identifier
1004050 module   ietf-yang-mpl-ops
1004051 data   /ietf-yang-mpl-domain:domain
                 /ietf-yang-mpl-ops:mpl-ops
1004052 data   /ietf-yang-mpl-domain:domain/ietf-yang-mpl-ops:
                 mpl-ops/PROACTIVE_FORWARDING
1004053 data   /ietf-yang-mpl-domain:domain/ietf-yang-mpl-ops:
                 mpl-ops/SEED_SET_ENTRY_LIFETIME
1004054 data   /ietf-yang-mpl-domain:domain/ietf-yang-mpl-ops:
                 mpl-ops/mpl-parameter
1004055 data   /ietf-yang-mpl-domain:domain/ietf-yang-mpl-ops:
                 mpl-ops/mpl-parameter/CONTROL_MESSAGE_IMAX
1004056 data   /ietf-yang-mpl-domain:domain/ietf-yang-mpl-ops:
                 mpl-ops/mpl-parameter/CONTROL_MESSAGE_IMIN
1004057 data   /ietf-yang-mpl-domain:domain/ietf-yang-mpl-ops:
                 mpl-ops/mpl-parameter/CONTROL_MESSAGE_K
1004058 data   /ietf-yang-mpl-domain:domain/ietf-yang-mpl-ops:
                 mpl-ops/mpl-parameter/CONTROL_MESSAGE_TIMER_EXPIRATIONS
1004059 data   /ietf-yang-mpl-domain:domain/ietf-yang-mpl-ops:
                 mpl-ops/mpl-parameter/DATA_MESSAGE_IMAX
1004060 data   /ietf-yang-mpl-domain:domain/ietf-yang-mpl-ops:
                 mpl-ops/mpl-parameter/DATA_MESSAGE_IMIN
1004061 data   /ietf-yang-mpl-domain:domain/ietf-yang-mpl-ops:
                 mpl-ops/mpl-parameter/DATA_MESSAGE_K
1004062 data   /ietf-yang-mpl-domain:domain/ietf-yang-mpl-ops:
                 mpl-ops/mpl-parameter/DATA_MESSAGE_TIMER_EXPIRATIONS
1004063 data   /ietf-yang-mpl-domain:domain/ietf-yang-mpl-ops:
                 mpl-ops/mpl-parameter/domainID

3.3. mpl-seeds
Module: ietf-yang-mpl-seeds
Revision: 2018-07-06

3.4. mpl-statistics

Module: ietf-yang-mpl-statistics
Revision: 2018-07-06
ietf-yang-mpl-statistics:mpl-statistics/c-too-high
1004153 data  /ietf-yang-mpl-domain:domain/
  ietf-yang-mpl-statistics:mpl-statistics/domainID
1004154 data  /ietf-yang-mpl-domain:domain/
  ietf-yang-mpl-statistics:mpl-statistics/nr-forwarded
1004155 data  /ietf-yang-mpl-domain:domain/
  ietf-yang-mpl-statistics:mpl-statistics
   /nr-of-consistent-control
1004156 data  /ietf-yang-mpl-domain:domain/
  ietf-yang-mpl-statistics:mpl-statistics
   /nr-of-consistent-data
1004157 data  /ietf-yang-mpl-domain:domain/
  ietf-yang-mpl-statistics:mpl-statistics
   /nr-of-copies-forwarded
1004158 data  /ietf-yang-mpl-domain:domain/
  ietf-yang-mpl-statistics:mpl-statistics
   /nr-of-copies-received
1004159 data  /ietf-yang-mpl-domain:domain/
  ietf-yang-mpl-statistics:mpl-statistics
   /nr-of-inconsistent-control
1004160 data  /ietf-yang-mpl-domain:domain/
  ietf-yang-mpl-statistics:mpl-statistics
   /nr-of-inconsistent-data
1004161 data  /ietf-yang-mpl-domain:domain/
  ietf-yang-mpl-statistics:mpl-statistics
   /nr-of-messages-forwarded
1004162 data  /ietf-yang-mpl-domain:domain/
  ietf-yang-mpl-statistics:mpl-statistics
   /nr-of-messages-received
1004163 data  /ietf-yang-mpl-domain:domain/
  ietf-yang-mpl-statistics:mpl-statistics
   /nr-of-missed-messages
1004164 data  /ietf-yang-mpl-domain:domain/
  ietf-yang-mpl-statistics:mpl-statistics
   /nr-of-notreceived-messages
1004165 data  /ietf-yang-mpl-domain:domain/
  ietf-yang-mpl-statistics:mpl-statistics
   /nr-of-refused-copies
1004166 data  /ietf-yang-mpl-domain:domain/
  ietf-yang-mpl-statistics:mpl-statistics
   /seedID
1004167 data  /ietf-yang-mpl-domain:domain/
  ietf-yang-mpl-statistics:mpl-statistics
   /statistics-interval
4. yang-mpl modules

This section describes the four yang modules. The modules are based on the MPL specification published in [RFC7731] and the specification of [RFC6206]. The identification of the interfaces follows the specification of ietf-interfaces of [RFC8343].

The data model allows to set values to the parameters of the MPL algorithm. This approach requires an active manager process to set the values without use of DHCP as described in: [RFC7774].

The names of the four modules are: yang-mpl-domain, yang-mpl-ops, yang-mpl-seeds, and yang-mpl-statistics, described in subsections with the same name.

4.1. yang-mpl-domain module

This module describes (1) the MPL domains and the associated multicast addresses, and (2) the interfaces and the multicast addresses for which they are enabled.

The model features a choice such that:

the model specifies for constrained devices with only one "single" interface and only one "single" domain, a list of MC addresses for which the single interface is enabled.

the model specifies for larger devices "multiple" interface and "multiple" domains, a list of MC addresses for which one or more interfaces are enabled.

<CODE BEGINS> file "ietf-yang-mpl-domain@2018-07-06.yang"

module ietf-yang-mpl-domain {
    yang-version 1.1;
    namespace
    prefix mpl;
    import ietf-inet-types{
        prefix inet;
    }
}

van der Stok Expires January 16, 2019 [Page 11]
organization
"IETF ROLL (Routing Over Low power and lossy networks) Working Group";

contact
"WG Web: http://tools.ietf.org/wg/roll/
WG List: mailto:roll@ietf.org

WG Chair: Peter van der Stok
mailto:consultancy@vanderstok.org

WG Chair: Ines Robles
mailto:maria.ines.robles@ericsson.com

Editor: Peter van der Stok
mailto:consultancy@vanderstok.org";

description
"This module contains information about the state of the MPL domain.

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  description "revision 3";
  reference
    "I-D:draft-ietf-roll-mpl-yang: A YANG model for Multicast Protocol for Low power and lossy Networks (MPL)";
}

container domain {
  description
    "High level container containing the choice statement between single domain/interface and multiple domains and interfaces.";

  choice multiple {
    description
      "A choice for large devices with multiple domains";
and interfaces.

container mpl-domain {
    description "The entries describe the MPL domains, the associated Multicast addresses and interfaces.";

    list domains {
        key domainID;
        description "The entries describe a given domain identified with domainID and the associated Multicast addresses.";

        leaf domainID {
            type uint16;
            description "Entry uniquely identifies the domain in the forwarder.";
        }

        leaf-list MList {
            type inet:ipv6-address;
            description "List of associated IPv6 Addresses.";
        }
    }  // domains list

    list addresses {
        key MCaddress;
        description "The entries describe the interfaces enabled with the specified MC address.";

        leaf MCaddress {
            type inet:ipv6-address;
            description "MC address belonging to a MPL domain.";
        }

        leaf-list interfaces {
            type string;
            description "List of names of interfaces enabled for this Multicast address. Interface name is defined in Appendix A of [RFC8343].";
        }
    }  // addresses list
}  // container mpl-domain

container mpl-single {


description
   "A choice for constrained devices with a list of
   MC addresses for single interface and domain."
leaf-list MCaddresses{
   type inet:ipv6-address;
   description
   "list of MC addresses belonging to one single
   domain and interface."
}
} // container mpl-simple
} // choice simple
} // container module
} //module ietf-yang-mpl-domain

4.2. yang-mpl-ops module

This module models the operational aspects of MPL. Per domain MPL
specifies four parameters I_MAX, I_MIN, K, and TIMER_EXPIRATIONs for
data and control messages. The value of the MPL intervals are
expressed in TUNIT. The entry SE_LIFETIME taken over from [RFC7774]
fixes TUNIT to milliseconds. For very constrained devices with only
one domain there can be only one instance of mpl-parameter list. The
module augments the ietf-yang-mpl-domain module.

<CODE BEGINS>file "ietf-yang-mpl-ops@2018-07-06.yang"

module ietf-yang-mpl-ops {
   yang-version 1.1;

   namespace
   prefix "mplo";

   import ietf-yang-mpl-domain{
      prefix "mpl";
   }

   organization
      "IETF ROLL (Routing over Low power and lossy networks)
      Working Group";

   contact

   van der Stok

Expires January 16, 2019

[Page 14]
description
"This module contains information about the operation of the MPL protocol.

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revision "2018-07-06" {
  description "revision 3";
  reference
    "I-D:draft-ietf-roll-mpl-yang: A YANG model for Multicast Protocol for Low power and lossy Networks (MPL)";
}

augment "/mpl:domain" {
  description
    "additional MPL server settings to MPL domains";

  container mpl-ops {
    description
      "Parameter settings for each MPL server and for each individual domain of the server.";

    leaf PROACTIVE_FORWARDING {
      type boolean;
    }
  }
}
description
"The boolean value indicates whether the MPL forwarder
schedules MPL data message transmission after
receiving them for the first time.
Specified in section 5.4 of [RFC7731];"
}

leaf SEED_SET_ENTRY_LIFETIME {
  type uint64;
  units "seconds";
  default 1800;
  description
  "The value indicates the minimum lifetime for
  an entry in the Seed set expressed in seconds.
  Default value is 30 minutes.
  Specified in section 5.4 of [RFC7731];"
}

list mpl-parameter{
  key domainID;
  description
  "Each domain has a set of MPL forwarding parameters
  which regulate the forwarding operation.";

  leaf domainID{
    type uint16;
    description
    "Each domainID must be present in
    mpl-parameter list.";
  }

  leaf DATA_MESSAGE_IMIN{
    type uint16;
    description
    "The minimum Trickle timer interval
    for MPL Data Message transmissions.\n    mpl-ops/mpl-parameter/DATA_MESSAGE_IMIN <=
    mpl-seeds/buffered-messages/I <=
    mpl-ops/mpl-parameter/DATA_MESSAGE_IMAX
    Specified in section 5.4 of [RFC7731];"
  }

  leaf DATA_MESSAGE_IMAX{
    type uint16;
    description
    "The maximum Trickle timer interval
    for MPL Data Message transmissions.\n    mpl-ops/mpl-parameter/DATA_MESSAGE_IMIN <=
leaf DATA_MESSAGE_K{
  type uint16;
  default 1;
  description
  "The redundancy constant
  for MPL Data Message transmissions.
  Specified in section 5.4 of [RFC7731]";
}

leaf DATA_MESSAGE_TIMER_EXPIRATIONS{
  type uint16;
  default 3;
  description
  "The number of Trickle timer expirations, as
  that occur before terminating the Trickle
  algorithm’s retransmission of a given
  MPL Data Message.
  Specified in section 5.4 of [RFC7731]";
}

leaf CONTROL_MESSAGE_IMIN{
  type uint16;
  description
  "The minimum Trickle timer interval
  for MPL Control Message transmissions.
  Specified in section 5.4 of [RFC7731]";
}

leaf CONTROL_MESSAGE_IMAX{
  type uint16;
  description
  "The maximum Trickle timer interval
  for MPL Control Message transmissions.
  Specified in section 5.4 of [RFC7731]";
}

leaf CONTROL_MESSAGE_K{
  type uint16;
  default 1;
  description
  "The redundancy constant
  for MPL Control Message transmissions.
  Specified in section 5.4 of [RFC7731]";
}
4.3.  yang-mpl-seeds module

This module specifies the current values of the operation of the MPL
forwarder. The values are acquired by the client and set by the
server. The module specifies a set of message buffers, with a buffer
per seed and domain. In constrained devices there will be only one
domain, but probably multiple seeds.

The message buffer contains a set of messages where each message is
uniquely identified by its sequence number and seed. The associated
I, c, e, and t values indicate the progress of MPL with respect to
this message, as specified in [RFC7731]. A forwarder sends and
receives multiple copies of a message. When a forwarder has sent
(received) a copy of a message, the forwarder has sent (received)
that message.

For forwarders which are seeds, local has value true and seqno is the
sequence number of the next message to send.

The module augments the ietf-yang-mpl-domain module.

<CODE BEGINS>file "ietf-yang-mpl-seeds@2018-07-06.yang"

module ietf-yang-mpl-seeds {
  yang-version 1.1;

  leaf CONTROL_MESSAGE_TIMER_EXPIRATIONS{
    type uint16;
    default 10;
    description
      "The number of Trickle time expirations,
       that occur before terminating the Trickle
algorithm for MPL Control Message
transmissions.
Specified in section 5.4 of [RFC7731];"
  }
}

<CODE ENDS>
namespace

prefix "mplse";

import ietf-yang-mpl-domain{
   prefix "mpl";
}

organization
   "IETF ROLL (Routing over Low power and lossy networks)
    Working Group"

contact
   "WG Web:   http://tools.ietf.org/wg/roll/
    WG List:  mailto:roll@ietf.org

    WG Chair: Peter van der Stok
              mailto:consultancy@vanderstok.org

    WG Chair: Ines Robles
              mailto:maria.ines.robles@ericsson.com

    Editor:   Peter van der Stok
              mailto:consultancy@vanderstok.org"

description
   "This module contains information about the operation
    of the MPL protocol.

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revision "2018-07-06" {
   description "revision 3";
   reference
      "I-D:draft-ietf-roll-mpl-yang: A YANG model for Multicast
Protocol for Low power and lossy Networks (MPL)"
}

augment "/mpl:domain" {
    description "additional message buffer status to MPL domains";

    leaf SE_LIFETIME {
        type uint16;
        units "milliseconds/timer units";
        description
            "Conversion from clock ticks to milliseconds,
             equivalent to SEED_SET_ENTRY_LIFETIME/TUNIT as
             specified in [RFC7774].";
    }

    list mpl-seeds{
        key "seedID domainID";
        config false;
        description
            "List describes all seeds that are active in the
             server. Seed information contains the message buffer
             contents and the operational values of I, c, sequence
             number and the life-times per message.";

        leaf seedID{
            type uint64;
            description
                "value uniquely identifies the MPL Seed within a MPL
                domain.";
        }

        leaf domainID{
            type uint16;
            description
                "together with seedID uniquely identifies buffer
                set.";
        }

        leaf local {
            type boolean;
            description
                "When local == true, seed originated in this
                 forwarder.
                When local == false, seed originated in different
                 forwarder.";
        }
    }

    leaf SEED_SET_ENTRY_LIFETIME {
        type uint32;
        units "milliseconds/timer units";
        description
            "Conversion from clock ticks to milliseconds,
             equivalent to SEED_SET_ENTRY_LIFETIME/TUNIT as
             specified in [RFC7774].";
    }

    leaf SEED_SET_ENTRY_LIFETIME {
        type uint32;
        units "milliseconds/timer units";
        description
            "Conversion from clock ticks to milliseconds,
             equivalent to SEED_SET_ENTRY_LIFETIME/TUNIT as
             specified in [RFC7774].";
    }

    leaf SEED_SET_ENTRY_LOCAL {
        type boolean;
        description
            "When local == true, seed originated in this
             forwarder.
                When local == false, seed originated in different
                 forwarder.";
        }

    leaf SEED_SET_ENTRY_LOCAL {
        type boolean;
        description
            "When local == true, seed originated in this
             forwarder.
                When local == false, seed originated in different
                 forwarder.";
    }

    leaf SEED_SET_ENTRY_SEQNUMBER {
        type uint64;
        description
            "Sequence number for each seed.
             This value is increasing with each seed.";
    }

    leaf SEED_SET_ENTRY_SEQNUMBER {
        type uint64;
        description
            "Sequence number for each seed.
             This value is increasing with each seed.";
    }

    leafSEED_SET_ENTRY_TIMERUNITS {
        type uint32;
        units "milliseconds/timer units";
        description
            "Conversion from clock ticks to milliseconds,
             equivalent to SEED_SET_ENTRY_LIFETIME/TUNIT as
             specified in [RFC7774].";
    }

    leaf SEED_SET_ENTRY_TIMERUNITS {
        type uint32;
        units "milliseconds/timer units";
        description
            "Conversion from clock ticks to milliseconds,
             equivalent to SEED_SET_ENTRY_LIFETIME/TUNIT as
             specified in [RFC7774].";
    }

    leaf SEED_SET_ENTRY_TIMERUNITS {
        type uint32;
        units "milliseconds/timer units";
        description
            "Conversion from clock ticks to milliseconds,
             equivalent to SEED_SET_ENTRY_LIFETIME/TUNIT as
             specified in [RFC7774].";
    }

    leaf SEED_SET_ENTRY_TIMERUNITS {
        type uint32;
        units "milliseconds/timer units";
        description
            "Conversion from clock ticks to milliseconds,
             equivalent to SEED_SET_ENTRY_LIFETIME/TUNIT as
             specified in [RFC7774].";
    }

    leaf SEED_SET_ENTRY_TIMERUNITS {
        type uint32;
        units "milliseconds/timer units";
        description
            "Conversion from clock ticks to milliseconds,
             equivalent to SEED_SET_ENTRY_LIFETIME/TUNIT as
             specified in [RFC7774].";
    }

    leaf SEED_SET_ENTRY_TIMERUNITS {
        type uint32;
        units "milliseconds/timer units";
        description
            "Conversion from clock ticks to milliseconds,
             equivalent to SEED_SET_ENTRY_LIFETIME/TUNIT as
             specified in [RFC7774].";
    }

    leaf SEED_SET_ENTRY_TIMERUNITS {
        type uint32;
        units "milliseconds/timer units";
        description
            "Conversion from clock ticks to milliseconds,
             equivalent to SEED_SET_ENTRY_LIFETIME/TUNIT as
             specified in [RFC7774].";
    }

    leaf SEED_SET_ENTRY_TIMERUNITS {
        type uint32;
        units "milliseconds/timer units";
        description
            "Conversion from clock ticks to milliseconds,
             equivalent to SEED_SET_ENTRY_LIFETIME/TUNIT as
             specified in [RFC7774].";
    }

    leaf SEED_SET_ENTRY_TIMERUNITS {
        type uint32;
        units "milliseconds/timer units";
        description
            "Conversion from clock ticks to milliseconds,
             equivalent to SEED_SET_ENTRY_LIFETIME/TUNIT as
             specified in [RFC7774].";
    }

    leaf SEED_SET_ENTRY_TIMERUNITS {
        type uint32;
        units "milliseconds/timer units";
        description
            "Conversion from clock ticks to milliseconds,
             equivalent to SEED_SET_ENTRY_LIFETIME/TUNIT as
             specified in [RFC7774].";
    }

    leaf SEED_SET_ENTRY_TIMERUNITS {
        type uint32;
        units "milliseconds/timer units";
        description
            "Conversion from clock ticks to milliseconds,
             equivalent to SEED_SET_ENTRY_LIFETIME/TUNIT as
             specified in [RFC7774].";
    }

    leaf SEED_SET_ENTRY_TIMERUNITS {
        type uint32;
        units "milliseconds/timer units";
        description
            "Conversion from clock ticks to milliseconds,
             equivalent to SEED_SET_ENTRY_LIFETIME/TUNIT as
             specified in [RFC7774].";
    }

    leaf SEED_SET_ENTRY_TIMERUNITS {
        type uint32;
        units "milliseconds/timer units";
        description
            "Conversion from clock ticks to milliseconds,
leaf generate-seqno {
    type uint8;
    description
        "Sequence number of next message to be generated by
         this local seed.";
}

leaf life-time {
    type uint64;
    units         "milliseconds";
    description
        "Minimum remaining lifetime of the seed entry in
         milliseconds.";
}

leaf min-seqno{
    type uint8;
    description
        "Lower bound sequence number in the buffer of the
         seed.";
}

leaf data-number{
    type uint8;
    description
        "Number of currently buffered data messages.";
}

leaf control-number{
    type uint8;
    description
        "Number of currently buffered control messages.";
}

list buffered-messages{
    key seqno;
    description
        "status of trickle intervals of the buffered message
         identified by seqno. and seed/domain";

    leaf seqno{
        type uint8;
        description
            "Sequence number of message.";
    }

    leaf I{
        type uint8;
    }

4.4. yang-mpl-statistics module

This module specifies the operation of the MPL forwarder expressed in number of messages and copies. The values are acquired by the client and set by the server. Statistics are specified per seed and domain.
In constrained devices there will be only one domain, but probably multiple seeds.

The parameter \( k \) determines how many copies of a message can be forwarded. The counters \( c\text{-too-high} \), \( nr\text{-forwarded} \), and \( nr\text{-not-forwarded} \) give insight in the consequences of the current value of \( k \).

The other counters give insight in the loss of messages caused by the medium or forwarding delays. The inconsistent/consistent counters indicate when consistent or inconsistent messages were received according to the definition of consistent in [RFC7731].

The module augments the ietf-yang-mpl-domain module.

<CODE BEGINS>file "ietf-yang-mpl-statistics@2018-07-06.yang"

module ietf-yang-mpl-statistics {
  yang-version 1.1;

  namespace

  prefix "mplst";

  import ietf-yang-mpl-domain{
    prefix "mpl";
  }

  organization
    "IETF ROLL (Routing over Low power and lossy networks)
     Working Group";

  contact
    "WG Web:   http://tools.ietf.org/wg/roll/
     WG List:  mailto:roll@ietf.org

    WG Chair: Peter van der Stok
     mailto:consultancy@vanderstok.org

    WG Chair: Ines Robles
     mailto:maria.ines.robles@ericsson.com

    Editor:   Peter van der Stok
     mailto:consultancy@vanderstok.org";

<CODE ENDS>
description
"This module contains information about the operation
of the MPL protocol.

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authors of the code. All rights reserved.

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Relating to IETF Documents
(http://trustee.ietf.org/license-info).

This version of this YANG module is part of RFC XXXX; see
the RFC itself for full legal notices.";

revision "2018-07-06" {
  description "revision 3";
  reference
    "I-D:draft-ietf-roll-mpl-yang: A YANG model for Multicast
    Protocol for Low power and lossy Networks (MPL)";
}

augment "/mpl:domain" {
  description "additional MPL message statistics to MPL
domains";

  list mpl-statistics{
    key "seedID domainID";
    config false;

    description
      "List describes performance statistics integrated over
      the messages identified by seed and domain identifiers.
      A forwarder can receive and forward multiple copies of
      a message uniquely identified by seqno, domain, and
      seed.";

    leaf seedID{
      type uint64;
      description
        "value uniquely identifies the MPL Seed within a MPL
domain.";
    }
}
leaf nr-of-refused-copies{
  type uint64;
  description
    "number of refused copies because seqno too small.";
}

leaf nr-of-missed-messages{
  type uint64;
  description
    "number of messages that were not received
     because seqno < min-seqno.";
}

leaf nr-of-notreceived-messages{
  type uint64;
  description
    "number of messages that were not received
     according to control message.";
}

leaf nr-of-inconsistent-data{
  type uint64;
  description
    "number of inconsistent data messages.";
}

leaf nr-of-consistent-data{
  type uint64;
  description
    "number of consistent data messages.";
}

leaf nr-of-consistent-control{
  type uint64;
  description
    "number of consistent control messages.";
}

leaf nr-of-inconsistent-control{
  type uint64;
  description
    "number of inconsistent control messages.";
}

leaf statistics-interval{
  type uint64;
  description
    "Interval, expressed in seconds, during which
the statistics are collected.
}

action reset-buffer-statistics{
    description
    "set all statistics counters and statistics-interval of buffer[seedID domainID] to zero.";
}

} // list mpl statistics

action reset-all-statistics{
    description
    "set all statistics counters and statistics-interval of all buffers to zero.";
}

} // augment
} // module ietf-yang-mpl-statistics

<CODE ENDS>

5. IANA Considerations

Registration of four YANG modules and corresponding SID files in the "YANG module assignment" registry is required.

module: ietf-yang-mpl-domain

.yang file: ietf-yang-mpl-domain@2018-07-06.yang
.sid file: ietf-yang-mpl-domain@2018-07-06.sid

module: ietf-yang-mpl-ops

.yang file: ietf-yang-mpl-ops@2018-07-06.yang
.sid file: ietf-yang-mpl-ops@2018-07-06.sid

module: ietf-yang-mpl-seeds
6. Acknowledgements

Andy Bierman has commented on the use of YANG for mpl. Many thanks to Radi Krejci for yang review.

7. Changelog

Changes from version 01 to version 02

- Added NMDA section.
- added module explanation in model section
- IANA considerations added

Changes from version 00 to version 01

- config false in "statistics" and "seeds" modules
- separated into 4 modules
- inserted choice in domain modules
- more explanatory text
- renamed some parameters
- Introduced section per module
- reset of statistics is added

Version ietf-00 copied from version vanderstok-02
8. References

8.1. Normative References

[I-D.ietf-core-sid]


8.2. Informative References

[I-D.ietf-netmod-yang-tree-diagrams]


Author’s Address

Peter van der Stok (editor)
consultant

Phone: +31-492474673 (Netherlands), +33-966015248 (France)
Email: consultancy@vanderstok.org
URI: www.vanderstok.org