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K. Korte
J. Schoenwaelder
A. Sehgal
Jacobs University
T. Tsou
Huawei Technologies (USA)
C. Zhou
Huawei Technologies

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Definition of Managed Objects for the IPv6 Routing Protocol for Low Power and Lossy Networks (RPL) draft-sehgal-roll-rpl-mib-04

Abstract

This memo defines a portion of the Management Information Base (MIB) for use with network management protocols in the Internet community. In particular, it defines objects for managing the IPv6 Routing Protocol for Low Power and Lossy Networks (RPL).

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 January 7, 2013.

Table of Contents

1. Introduction

This memo defines a portion of the Management Information Base (MIB) for use with network management protocols. In particular it defines objects for managing the IPv6 Routing Protocol for Low Power and Lossy Networks (RPL) [RFC6550]. It also provides management access to the Trickle [RFC6206] parameters as they are used by RPL.

2. The Internet-Standard Management Framework

For a detailed overview of the documents that describe the current Internet-Standard Management Framework, please refer to section 7 of RFC 3410 [RFC3410].

Managed objects are accessed via a virtual information store, termed the Management Information Base or MIB. MIB objects are generally accessed through the Simple Network Management Protocol (SNMP). Objects in the MIB are defined using the mechanisms defined in the Structure of Management Information (SMI). This memo specifies a MIB module that is compliant to the SMIv2, which is described in STD 58, RFC 2578 [RFC2578], STD 58, RFC 2579 [RFC2579] and STD 58, RFC 2580 [RFC2580].

3. Conventions

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].

4. Overview

The MIB module is organized into a group of scalars and tables.

```
# RPL-MIB registration tree (generated by smidump 0.4.8)

-rplMib(1.3.6.1.2.1.XXXX)
```

```
   +-rplNotifications(0)
   +-rplObjects(1)
      +-rplGeneral(1)
      |  +- rwn RplDISMode rplDefaultDISMode(1)
      +-rplActive(2)
      |  +- rwn RplInstanceID   rplActiveInstance(1)
      |  +- rwn InetAddressIPv6 rplActiveDodag(2)
      |  +- r-n Unsigned32      rplActiveDodagDAOSequence(3)
      |  +- rwn Unsigned32      rplActiveDodagTriggerSequence(4)
      +-rplOCPTable(3)
      |  +-rplOCPEntry(1) [rplOCPCodepoint]
      |     +- --- RplObjectiveCodePoint rplOCPCodepoint(1)
```



```
      |     +- rwn TruthValue            rplOCPEnabled(2)
      +-rplInstanceTable(4)
      |  +-rplInstanceEntry(1) [rplInstanceID]
      |     +- --- RplInstanceID         rplInstanceID(1)
      |     +- rwn RplObjectiveCodePoint rplInstanceOCP(2)
      |     +- rwn RplDISMode            rplInstanceDisMode(3)
      |     +- rwn TruthValue            rplInstanceDAOAckEnabled(4)
      |     +- rwn RplModeOfOperation    rplInstanceModeOfOperation(5)
      +-rplDodagTable(5)
      |  +-rplDodagEntry(1) [rplInstanceID,rplDodagRoot]
      |     +- --- InetAddressIPv6       rplDodagRoot(1)
      |     +- r-n RplDodagVersionNumber rplDodagVersion(2)
      |     +- r-n RplRank               rplDodagRank(3)
      |     +- r-n Enumeration           rplDodagState(4)
      |     +- r-n RplDAODelay           rplDodagDAODelay(5)
      |     +- r-n RplDodagPreference    rplDodagPreference(6)
      |     +- r-n RplMinHopRankIncrease rplDodagMinHopRankIncrease(7)
      |     +- r-n Unsigned32            rplDodagMaxRankIncrease(8)
      |     +- rwn Unsigned32            rplDodagIntervalDoublings(9)
      |     +- rwn Unsigned32            rplDodagIntervalMin(10)
      |     +- rwn Unsigned32            rplDodagRedundancyConstant(11)
      |     +- r-n RplPathControlSize    rplDodagPathControlSize(12)
      +-rplDodagParentTable(6)
      |  +-rplDodagParentEntry(1) [rplInstanceID,rplDodagRoot,
      |     |                        rplDodagParentID]
      |     +- --- InetAddressIPv6 rplDodagParentID(1)
      |     +- r-n InterfaceIndex  rplDodagParentIf(2)
      +-rplDodagChildTable(7)
      |  +-rplDodagChildEntry(1) [rplInstanceID,rplDodagRoot,
```

```
|     |                        rplDodagChildID]
|     +- r-n InetAddressIPv6 rplDodagChildID(1)
+-rplDodagPrefixTable(8)
|  +-rplDodagPrefixEntry(1) [rplInstanceID,rplDodagRoot,
|     |                         rplDodagPrefixIpv6Prefix,
|     |                         rplDodagPrefixIpv6PrefixLength]
|     +- r-n InetAddressIPv6         rplDodagPrefixIpv6Prefix(1)
|     +- r-n InetAddressPrefixLength
|                                rplDodagPrefixIpv6PrefixLength(2)
+-rplStats(9)
|  +- r-n Counter32 rplMemOverflows(1)
|  +- r-n Counter32 rplParseErrors(2)
|  +- r-n Counter32 rplUnknownMsgTypes(3)
|  +- r-n Counter32 rplSecurityPolicyViolations(4)
|  +- r-n Counter32 rplIntegrityCheckFailures(5)
|  +- r-n Counter32 rplReplayProtectionFailures(6)
|  +- r-n Counter32 rplValidParentFailures(7)
|  +- r-n Counter32 rplNoInstanceIDs(8)
|  +- r-n Counter32 rplTriggeredLocalRepairs(9)
```



```
|  +- r-n Counter32 rplTriggeredGlobalRepairs(10)
|  +- r-n Counter32 rplNoParentSecs(11)
|  +- r-n Counter32 rplActiveNoParentSecs(12)
|  +- r-n Counter32 rplOBitSetDownwards(13)
|  +- r-n Counter32 rplOBitClearedUpwards(14)
|  +- r-n Counter32 rplFBitSet(15)
|  +- r-n Counter32 rplRBitSet(16)
|  +- r-n Counter32 rplTrickleTimerResets(17)
+-rplMsgStatsTable(10)
   +-rplMsgStatsEntry(1) [rplMsgStatsType]
      +- --- RplMessageType rplMsgStatsType(1)
      +- r-n Counter32      rplMsgStatsInMsgs(2)
      +- r-n Counter32      rplMsgStatsOutMsgs(3)
```

5. Relationship to Other MIB Modules

The MIB module IMPORTS definitions from SNMPv2-SMI [RFC2578], SNMPv2-TC [RFC2579], SNMPv2-CONF [RFC2580], IF-MIB [RFC2863] and the INET-ADDRESS-MIB [RFC4001].

The IPv6 routing table should be exposed via the inetCidrRouteTable defined in the IP-FORWARD-MIB [RFC4292]. XXX: We need to clarify

whether the inetCidrRoutePolicy can / should point to the DODAG instance.

6. Definitions

```
RPL-MIB DEFINITIONS ::= BEGIN

IMPORTS
    MODULE-IDENTITY, OBJECT-TYPE, Unsigned32, Counter32, mib-2
        FROM SNMPv2-SMI                                  -- RFC 2578
    TEXTUAL-CONVENTION, TruthValue
        FROM SNMPv2-TC                                   -- RFC 2579
    OBJECT-GROUP, MODULE-COMPLIANCE
        FROM SNMPv2-CONF                                 -- RFC 2580
    InterfaceIndex
        FROM IF-MIB                                      -- RFC 2863
    InetAddressIPv6, InetAddressPrefixLength
        FROM INET-ADDRESS-MIB;                           -- RFC 4001

rplMib MODULE-IDENTITY
    LAST-UPDATED "201207060000Z"
    ORGANIZATION
        "Jacobs University Bremen"
    CONTACT-INFO
        "Kevin Dominik Korte
         Jacobs University Bremen
```


Email: k.korte@jacobs-university.de

Anuj Sehgal
Jacobs University Bremen
Email: s.anuj@jacobs-university.de

Juergen Schoenwaelder
Jacobs University Bremen
Email: j.schoenwaelder@jacobs-university.de

Tina Tsou
Huawei Technologies
Email: tina.tsou.zouting@huawei.com

Cathy Zhou

```
            Huawei Technologies
            Email: cathyzhou@huawei.com"
        DESCRIPTION
            "The MIB module for monitoring nodes implementing the IPv6
             routing protocol for low power and lossy networks (RPL).

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             authors of the code.  All rights reserved.

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             (http://trustee.ietf.org/license-info)."

        REVISION "201207060000Z"
        DESCRIPTION
            "Initial version, published as RFC XXXX."
        -- RFC Ed.: replace XXXX with actual RFC number & remove this note

        ::= { mib-2 XXXX }

    -- XXX: Do we keep all types (textual conventions) defined below or
    -- XXX  do we inline those that only get used once?

    RplMessageType ::= TEXTUAL-CONVENTION
        DISPLAY-HINT "d"
        STATUS      current
        DESCRIPTION
            "The type of an RPL control message as defined in Section
             6 of RFC 6550."
        REFERENCE
```



```
            "RFC 6550: RPL: IPv6 Routing Protocol for LLNs"
        SYNTAX      Unsigned32 (0..255)

    RplInstanceID ::=  TEXTUAL-CONVENTION
        DISPLAY-HINT "d"
        STATUS      current
        DESCRIPTION
            "A global or local RPLinstanceID as defined in Section 5.1. of
```

```
            RFC 6550."
      REFERENCE
          "RFC 6550: RPL: IPv6 Routing Protocol for LLNs"
      SYNTAX      Unsigned32 (0..255)

  RplDodagVersionNumber ::= TEXTUAL-CONVENTION
      DISPLAY-HINT "d"
      STATUS      current
      DESCRIPTION
          "The version number of a DODAG as defined in Section 6.3 of
            RFC 6550."
      REFERENCE
          "RFC 6550: RPL: IPv6 Routing Protocol for LLNs"
      SYNTAX      Unsigned32 (0..255)

  RplRank ::= TEXTUAL-CONVENTION
      DISPLAY-HINT "d"
      STATUS      current
      DESCRIPTION
          "The rank of a node within a DODAG as defined in Section 6.3
            of RFC 6550."
      REFERENCE
          "RFC 6550: RPL: IPv6 Routing Protocol for LLNs"
      SYNTAX      Unsigned32 (0..65535)

  RplObjectiveCodePoint ::= TEXTUAL-CONVENTION
      DISPLAY-HINT "d"
      STATUS      current
      DESCRIPTION
          "The Objective Code Point of a DODAG as defined in
           Section 6.7.6 of RFC 6550."
      REFERENCE
          "RFC 6550: RPL: IPv6 Routing Protocol for LLNs"
      SYNTAX      Unsigned32 (0..65535)

  RplDISMode ::= TEXTUAL-CONVENTION
      STATUS      current
      DESCRIPTION
          "Determines whether a DIS message is send upon boot-up
           or not as defined in Section 18.2.1.1 of RFC 6550:
```



```
           silent(1)  do not send DIS messages
```

```
            send(2)    send DIS messages"
        REFERENCE
            "RFC 6550: RPL: IPv6 Routing Protocol for LLNs"
        SYNTAX      INTEGER {
                        silent(1),
                        send(2)
                    }

    RplModeOfOperation ::= TEXTUAL-CONVENTION
        STATUS      current
        DESCRIPTION
            "Determines the mode of operation."
        REFERENCE
            "RFC 6550: RPL: IPv6 Routing Protocol for LLNs"
        SYNTAX      INTEGER {
                        noDownwardRoutes(0),
                        nonStoringMode(1),
                        storingWithoutMulticastSupport(2),
                        storingWithMulticastSupport(3)
                    }

    RplDAODelay ::= TEXTUAL-CONVENTION
        DISPLAY-HINT "d"
        STATUS      current
        DESCRIPTION
            "The delay time used for aggregation before a DAO message
             is send."
        REFERENCE
            "RFC 6550: RPL: IPv6 Routing Protocol for LLNs"
        SYNTAX      Unsigned32

    RplDodagPreference ::= TEXTUAL-CONVENTION
        DISPLAY-HINT "d"
        STATUS      current
        DESCRIPTION
            "The preference of a DODAG compared to another DODAG of the
             same instance as defined in Section 6.3 of RFC 6550."
        REFERENCE
            "RFC 6550: RPL: IPv6 Routing Protocol for LLNs"
        SYNTAX      Unsigned32 (0..7)

    RplMinHopRankIncrease ::= TEXTUAL-CONVENTION
        DISPLAY-HINT "d"
        STATUS      current
        DESCRIPTION
            "The minimal incerease of a rank within a single hop as
             defined in Section 6.7.6 of RFC 6550."
```

```
      REFERENCE
          "RFC 6550: RPL: IPv6 Routing Protocol for LLNs"
      SYNTAX      Unsigned32 (0..131071)

  RplPathControlSize ::= TEXTUAL-CONVENTION
      DISPLAY-HINT "d"
      STATUS      current
      DESCRIPTION
          "The Path Control Size within a DODAG as defined in
           Section 6.7.6 of RFC 6550."
      REFERENCE
          "RFC 6550: RPL: IPv6 Routing Protocol for LLNs"
      SYNTAX      Unsigned32 (0..7)

  -- object definitions

  rplNotifications OBJECT IDENTIFIER ::= { rplMib 0 }
  rplObjects       OBJECT IDENTIFIER ::= { rplMib 1 }
  rplConformance   OBJECT IDENTIFIER ::= { rplMib 2 }

  rplGeneral OBJECT IDENTIFIER ::= { rplObjects 1 }

  rplDefaultDISMode OBJECT-TYPE
      SYNTAX      RplDISMode
      MAX-ACCESS  read-write
      STATUS      current
      DESCRIPTION
          "Determines whether a DIS message is send upon boot-up.
           Changes to this value may not persist across restarts."
      ::= { rplGeneral 1 }
      -- XXX should be able to configure the number of DIS messages
      -- XXX and related timer, see 18.2.1.1.

      -- XXX Should there be more objects to configure default timers
      -- XXX etc that are applied to all DODAGs etc?

  rplActive OBJECT IDENTIFIER ::= { rplObjects 2 }

  rplActiveInstance OBJECT-TYPE
      SYNTAX       RplInstanceID
      MAX-ACCESS   read-write
      STATUS       current
      DESCRIPTION
          "The currently active RPL Instance. Changes to this value
           may not persist across restarts."
      ::= { rplActive 1 }
```

```
  rplActiveDodag OBJECT-TYPE
```



```
      SYNTAX      InetAddressIPv6
      MAX-ACCESS  read-write
      STATUS      current
      DESCRIPTION
          "The currently active RPL DODAG in the active RPL Instance.
           Changes to this value may not persist across restarts."
      ::= { rplActive 2 }

  rplActiveDodagDAOSequence OBJECT-TYPE
      SYNTAX      Unsigned32 (0..255)
      MAX-ACCESS  read-only
      STATUS      current
      DESCRIPTION
          "The DAO message sequence number (DAOSequence) of the active
           DODAG as defined in Section 6.5.1 of RFC 6550."
      REFERENCE
          "RFC 6550: RPL: IPv6 Routing Protocol for LLNs"
      ::= { rplActive 3 }
      -- XXX Does it really make sense to have this object?

  rplActiveDodagTriggerSequence OBJECT-TYPE
      SYNTAX      Unsigned32 (0..255)
      MAX-ACCESS  read-write
      STATUS      current
      DESCRIPTION
          "The DAO Trigger Sequence Number (DTSN) of the active
           DODAG as defined in Section 6.3.1 of RFC 6550. Changes to
           this value may not persist across restarts."
      REFERENCE
          "RFC 6550: RPL: IPv6 Routing Protocol for LLNs"
      ::= { rplActive 4 }

  rplOCPTable OBJECT-TYPE
      SYNTAX      SEQUENCE OF RplOCPEntry
      MAX-ACCESS  not-accessible
      STATUS      current
      DESCRIPTION
          "The table of all supported Objective Code Points (OCPs)."
      ::= { rplObjects 3 }
```

```
  rplOCPEntry OBJECT-TYPE
      SYNTAX      RplOCPEntry
      MAX-ACCESS  not-accessible
      STATUS      current
      DESCRIPTION
          "An entry representing a supported Objective Code Point."
      INDEX { rplOCPCodepoint }
      ::= { rplOCPTable 1 }
```



```
  RplOCPEntry ::= SEQUENCE {
      rplOCPCodepoint  RplObjectiveCodePoint,
      rplOCPEnabled    TruthValue
  }

  rplOCPCodepoint OBJECT-TYPE
      SYNTAX      RplObjectiveCodePoint
      MAX-ACCESS  not-accessible
      STATUS      current
      DESCRIPTION
          "A supported Objective Code Point."
      ::= { rplOCPEntry 1 }

  rplOCPEnabled OBJECT-TYPE
      SYNTAX      TruthValue
      MAX-ACCESS  read-write
      STATUS      current
      DESCRIPTION
          "Enables the usage of this Objective Code Point. Changes to
           this value may not persist across restarts."
      ::= { rplOCPEntry 2 }

  rplInstanceTable OBJECT-TYPE
      SYNTAX      SEQUENCE OF RplInstanceEntry
      MAX-ACCESS  not-accessible
      STATUS      current
      DESCRIPTION
          "The table represents information about all known
           RPL Instances."
      ::= { rplObjects 4 }

  rplInstanceEntry OBJECT-TYPE
```

```
    SYNTAX      RplInstanceEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "An entry representing information about a RPL Instance."
    INDEX { rplInstanceID }
    ::= { rplInstanceTable 1 }
    -- XXX This should likely be a read-create table.

RplInstanceEntry ::= SEQUENCE {
    rplInstanceID               RplInstanceID,
    rplInstanceOCP              RplObjectiveCodePoint,
    rplInstanceDisMode          RplDISMode,
    rplInstanceDAOAckEnabled    TruthValue,
    rplInstanceModeOfOperation  RplModeOfOperation
}
```



```
rplInstanceID OBJECT-TYPE
    SYNTAX      RplInstanceID
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The InstanceID of this RPL Instance."
    ::= { rplInstanceEntry 1 }

rplInstanceOCP OBJECT-TYPE
    SYNTAX      RplObjectiveCodePoint
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "The Objective Code Point of this RPL Instance. Changes to
         this value may not persist across restarts."
    ::= { rplInstanceEntry 2 }

rplInstanceDisMode OBJECT-TYPE
    SYNTAX      RplDISMode
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "Determines whether a DIS message is send for this instance
         upon boot-up. Changes to this value may not persist across
         restarts."
```

```
    ::= { rplInstanceEntry 3 }
    -- XXX Check how this works together with the global toggle.
    -- XXX should we allow per instance parameters such as the number
    -- XXX of DIS messages and related timer, see 17.2.1.1?

  rplInstanceDAOAckEnabled OBJECT-TYPE
      SYNTAX      TruthValue
      MAX-ACCESS  read-write
      STATUS      current
      DESCRIPTION
          "Indicates whether DAO Acknowledgements are sent on this
           RPL instance. Changes to this value may not persist across
           restarts."
      ::= { rplInstanceEntry 4 }

  rplInstanceModeOfOperation OBJECT-TYPE
      SYNTAX      RplModeOfOperation
      MAX-ACCESS  read-write
      STATUS      current
      DESCRIPTION
          "The mode of Operation of the RPL instance. Changes to this
           value may not persist across restarts."
      ::= { rplInstanceEntry 5 }
```



```
  rplDodagTable OBJECT-TYPE
      SYNTAX      SEQUENCE OF RplDodagEntry
      MAX-ACCESS  not-accessible
      STATUS      current
      DESCRIPTION
          "The table represents information about all locally known
           DODAGs."
      ::= { rplObjects 5 }
      -- XXX The root needs a bit(?) config, where does that go?

  rplDodagEntry OBJECT-TYPE
      SYNTAX      RplDodagEntry
      MAX-ACCESS  not-accessible
      STATUS      current
      DESCRIPTION
          "An entry representing information about a DODAG."
      INDEX { rplInstanceID, rplDodagRoot }
      ::= { rplDodagTable 1 }
```

```
  RplDodagEntry ::= SEQUENCE {
      rplDodagRoot                InetAddressIPv6,
      rplDodagVersion             RplDodagVersionNumber,
      rplDodagRank                RplRank,
      rplDodagState               INTEGER,
      rplDodagDAODelay            RplDAODelay,
      rplDodagPreference          RplDodagPreference,
      rplDodagMinHopRankIncrease  RplMinHopRankIncrease,
      rplDodagMaxRankIncrease     Unsigned32,
      rplDodagIntervalDoublings   Unsigned32,
      rplDodagIntervalMin         Unsigned32,
      rplDodagRedundancyConstant  Unsigned32,
      rplDodagPathControlSize     RplPathControlSize
  }

  rplDodagRoot OBJECT-TYPE
      SYNTAX      InetAddressIPv6
      MAX-ACCESS  not-accessible
      STATUS      current
      DESCRIPTION
          "The identifier of a DODAG root (DODAGID) of this RPL
           instance. The root of the DODAG reports its own IPv6
           address as the DODAG root."
      ::= { rplDodagEntry 1 }

  rplDodagVersion OBJECT-TYPE
      SYNTAX      RplDodagVersionNumber
      MAX-ACCESS  read-only
      STATUS      current
```



```
      DESCRIPTION
          "The version of the DODAG in this RPL instance."
      ::= { rplDodagEntry 2 }

  rplDodagRank OBJECT-TYPE
      SYNTAX      RplRank
      MAX-ACCESS  read-only
      STATUS      current
      DESCRIPTION
          "The rank of the node within the DODAG."
      ::= { rplDodagEntry 3 }
```

```
  rplDodagState OBJECT-TYPE
      SYNTAX      INTEGER {
                      other(0),
                      associated(1),
                      grounded(2),
                      floating(3)
                  }
      MAX-ACCESS  read-only
      STATUS      current
      DESCRIPTION
          "The status of the DODAG:

           other(0)      An unknown state.

           associated(1) A node is associated with the RPL instance.

           grounded(2)   The DODAG is grounded.

           floating(3)   The DODAG is floating (not grounded)."
      ::= { rplDodagEntry 4 }
      -- XXX In which circumstances can a node be associate and neither
      -- XXX grounded or floating?

  rplDodagDAODelay OBJECT-TYPE
      SYNTAX      RplDAODelay
      UNITS       "milliseconds"
      MAX-ACCESS  read-only
      STATUS      current
      DESCRIPTION
          "The delay for aggregations before a DAO is send."
      ::= { rplDodagEntry 5 }
      -- XXX Should this be configuration? If so we should add a default
      -- XXX clause to define the default value to be 1 second.

  rplDodagPreference OBJECT-TYPE
      SYNTAX      RplDodagPreference
```



```
      MAX-ACCESS  read-only
      STATUS      current
      DESCRIPTION
          "How preferred this DODAG is compared to other DODAGs
```

```
           within the same instance."
      ::= { rplDodagEntry 6 }

  rplDodagMinHopRankIncrease OBJECT-TYPE
      SYNTAX      RplMinHopRankIncrease
      MAX-ACCESS  read-only
      STATUS      current
      DESCRIPTION
          "The minimum increase of the rank in a single hop."
      ::= { rplDodagEntry 7 }
      -- XXX should this be writable at the root? If so we should add a
      -- defval clause to define the default value to be 256.

  rplDodagMaxRankIncrease OBJECT-TYPE
      SYNTAX      Unsigned32 (0..65535)
      MAX-ACCESS  read-only
      STATUS      current
      DESCRIPTION
           "The maximum allowable increase in rank in support of local
            repair.  If DAGMaxRankIncrease is 0 then this mechanism is
            disabled."
      ::= { rplDodagEntry 8 }

  rplDodagIntervalDoublings OBJECT-TYPE
      SYNTAX      Unsigned32 (0..255)
      MAX-ACCESS  read-write
      STATUS      current
      DESCRIPTION
          "The configured Imax of the DIO trickle timer. This is
           typically only writable at the root. Changes to this value
           may not persist across restarts."
      REFERENCE
          "RFC 6206: The Trickle Algorithm"
      DEFVAL      { 20 }
      ::= { rplDodagEntry 9 }

  rplDodagIntervalMin OBJECT-TYPE
      SYNTAX      Unsigned32 (0..255)
      MAX-ACCESS  read-write
      STATUS      current
      DESCRIPTION
          "The configured Imin of the DIO trickle timer. Changes to this
           value may not persist across restarts."
      REFERENCE
```

```
            "RFC 6206: The Trickle Algorithm"
        DEFVAL      { 3 }
        ::= { rplDodagEntry 10 }

    rplDodagRedundancyConstant OBJECT-TYPE
        SYNTAX      Unsigned32 (0..255)
        MAX-ACCESS  read-write
        STATUS      current
        DESCRIPTION
            "The configured k of the DIO trickle timer. Changes to this
             value may not persist across restarts."
        REFERENCE
            "RFC 6206: The Trickle Algorithm"
        DEFVAL      { 10 }
        ::= { rplDodagEntry 11 }

    rplDodagPathControlSize OBJECT-TYPE
        SYNTAX      RplPathControlSize
        MAX-ACCESS  read-only
        STATUS      current
        DESCRIPTION
            "The Path Control Size of this DODAG."
        ::= { rplDodagEntry 12 }

    rplDodagParentTable OBJECT-TYPE
        SYNTAX      SEQUENCE OF RplDodagParentEntry
        MAX-ACCESS  not-accessible
        STATUS      current
        DESCRIPTION
            "The list of parents for a DODAG."
        ::= { rplObjects 6 }

    rplDodagParentEntry OBJECT-TYPE
        SYNTAX      RplDodagParentEntry
        MAX-ACCESS  not-accessible
        STATUS      current
        DESCRIPTION
            "Information about a known DODAG parent."
        INDEX { rplInstanceID, rplDodagRoot, rplDodagParentID }
        ::= { rplDodagParentTable 1 }

    RplDodagParentEntry ::= SEQUENCE {
        rplDodagParentID     InetAddressIPv6,
        rplDodagParentIf     InterfaceIndex
    }

    rplDodagParentID OBJECT-TYPE
```

```
      SYNTAX      InetAddressIPv6
```



```
      MAX-ACCESS  not-accessible
      STATUS      current
      DESCRIPTION
          "An RPL parent associated with this DODAG."
      ::= { rplDodagParentEntry 1 }

  rplDodagParentIf OBJECT-TYPE
      SYNTAX      InterfaceIndex
      MAX-ACCESS  read-only
      STATUS      current
      DESCRIPTION
          "The interface over which the parent can be reached."
      ::= { rplDodagParentEntry 2 }

  rplDodagChildTable OBJECT-TYPE
      SYNTAX      SEQUENCE OF RplDodagChildEntry
      MAX-ACCESS  not-accessible
      STATUS      current
      DESCRIPTION
          "The list of children for a DODAG."
      ::= { rplObjects 7 }

  rplDodagChildEntry OBJECT-TYPE
      SYNTAX      RplDodagChildEntry
      MAX-ACCESS  not-accessible
      STATUS      current
      DESCRIPTION
          "Information about a known DODAG child."
      INDEX { rplInstanceID, rplDodagRoot, rplDodagChildID }
      ::= { rplDodagChildTable 1 }

  RplDodagChildEntry ::= SEQUENCE {
      rplDodagChildID InetAddressIPv6
  }

  rplDodagChildID OBJECT-TYPE
      SYNTAX      InetAddressIPv6
      MAX-ACCESS  read-only
      STATUS      current
      DESCRIPTION
```

```
            "An RPL child associated with this DODAG."
        ::= { rplDodagChildEntry 1 }

    rplDodagPrefixTable OBJECT-TYPE
        SYNTAX      SEQUENCE OF RplDodagPrefixEntry
        MAX-ACCESS  not-accessible
        STATUS      current
        DESCRIPTION
```



```
            "List of prefixes associated with a DODAG."
        ::= { rplObjects 8 }
        -- XXX Explain how this relates to the ipAddressPrefixTable in
        -- XXX the IP-MIB

    rplDodagPrefixEntry OBJECT-TYPE
        SYNTAX      RplDodagPrefixEntry
        MAX-ACCESS  not-accessible
        STATUS      current
        DESCRIPTION
            "Information about a prefix associated with a DODAG."
        INDEX { rplInstanceID, rplDodagRoot,
                rplDodagPrefixIpv6Prefix, rplDodagPrefixIpv6PrefixLength }
        ::= { rplDodagPrefixTable 1 }
        -- XXX Can a DODAG have multiple prefixes, i.e., do we have to
        -- XXX have the prefix and its length in the INDEX?

    RplDodagPrefixEntry ::= SEQUENCE {
        rplDodagPrefixIpv6Prefix       InetAddressIPv6,
        rplDodagPrefixIpv6PrefixLength InetAddressPrefixLength
    }

    rplDodagPrefixIpv6Prefix OBJECT-TYPE
        SYNTAX      InetAddressIPv6
        MAX-ACCESS  read-only
        STATUS      current
        DESCRIPTION
            "The IPv6 address forming the IPv6 prefix."
        ::= { rplDodagPrefixEntry 1 }

    rplDodagPrefixIpv6PrefixLength OBJECT-TYPE
        SYNTAX      InetAddressPrefixLength
        MAX-ACCESS  read-only
```

```
        STATUS      current
        DESCRIPTION
            "The length of the IPv6 prefix."
        ::= { rplDodagPrefixEntry 2 }

    rplStats OBJECT IDENTIFIER ::= { rplObjects 9 }

    rplMemOverflows OBJECT-TYPE
        SYNTAX      Counter32
        MAX-ACCESS  read-only
        STATUS      current
        DESCRIPTION
            "The number of memory allocation failures (e.g., routing table
             overflows)."
        ::= { rplStats 1 }
```



```
    rplParseErrors OBJECT-TYPE
        SYNTAX      Counter32
        MAX-ACCESS  read-only
        STATUS      current
        DESCRIPTION
            "The number of received malformed messages."
        ::= { rplStats 2 }

    rplUnknownMsgTypes OBJECT-TYPE
        SYNTAX      Counter32
        MAX-ACCESS  read-only
        STATUS      current
        DESCRIPTION
            "The number of received RPL messages that we dropped because
             the message type is not recognized by the implementation."
        ::= { rplStats 3 }

    rplSecurityPolicyViolations OBJECT-TYPE
        SYNTAX      Counter32
        MAX-ACCESS  read-only
        STATUS      current
        DESCRIPTION
            "The number of messages discarded because the described level
             of security for the message type and originator is unknown or
             does not meet locally maintained security policies as defined
             in Section 10.7. of RFC 6550."
```

```
        REFERENCE
            "RFC 6550: RPL: IPv6 Routing Protocol for LLNs"
        ::= { rplStats 4 }

    rplIntegrityCheckFailures OBJECT-TYPE
        SYNTAX      Counter32
        MAX-ACCESS  read-only
        STATUS      current
        DESCRIPTION
            "The number of messages discarded because the integrity
             check failed against the received message authentication
             code (MAC) as defined in Section 10.7. of RFC 6550."
        REFERENCE
            "RFC 6550: RPL: IPv6 Routing Protocol for LLNs"
        ::= { rplStats 5 }

    rplReplayProtectionFailures OBJECT-TYPE
        SYNTAX      Counter32
        MAX-ACCESS  read-only
        STATUS      current
        DESCRIPTION
            "The number of messages discarded because the received
```



```
             message Counter value is non-zero and less than the
             maintained incoming Counter watermark or because the
             received Timestamp Counter value indicates a message
             transmission time that is earlier than the Current time
             less the acceptable packet delay as defined in Section
             10.7. of RFC 6550. This counter is also incremented if the
             temporal consistency check of the message fails as defined
             in Section 10.7.1."
        REFERENCE
            "RFC 6550: RPL: IPv6 Routing Protocol for LLNs"
        ::= { rplStats 6 }

    rplValidParentFailures OBJECT-TYPE
        SYNTAX      Counter32
        MAX-ACCESS  read-only
        STATUS      current
        DESCRIPTION
            "The number of times a packet could not be sent to a DODAG
             parent flagged as valid."
```

```
      ::= { rplStats 7 }

  rplNoInstanceIDs OBJECT-TYPE
      SYNTAX      Counter32
      MAX-ACCESS  read-only
      STATUS      current
      DESCRIPTION
          "The number of times a packet could not be sent because of
           a missing RPLInstanceID."
      ::= { rplStats 8 }

  rplTriggeredLocalRepairs OBJECT-TYPE
      SYNTAX      Counter32
      MAX-ACCESS  read-only
      STATUS      current
      DESCRIPTION
          "The number of times a local repair procedure was triggered."
      ::= { rplStats 9 }

  rplTriggeredGlobalRepairs OBJECT-TYPE
      SYNTAX      Counter32
      MAX-ACCESS  read-only
      STATUS      current
      DESCRIPTION
          "The number of times a global repair procedure was triggered."
      ::= { rplStats 10 }

  rplNoParentSecs OBJECT-TYPE
      SYNTAX      Counter32
```



```
      MAX-ACCESS  read-only
      STATUS      current
      DESCRIPTION
          "The number of seconds without a next hop (DODAG parent)."
      ::= { rplStats 11 }

  rplActiveNoParentSecs OBJECT-TYPE
      SYNTAX      Counter32
      MAX-ACCESS  read-only
      STATUS      current
      DESCRIPTION
          "The number of seconds with packets to forward without a
```

```
            next hop (DODAG parent)."
        ::= { rplStats 12 }

    rplOBitSetDownwards OBJECT-TYPE
        SYNTAX      Counter32
        MAX-ACCESS  read-only
        STATUS      current
        DESCRIPTION
            "Number of packets received with the 'O' bit set from
             a node with a higher rank as defined in Section 18.3.2
             of RFC 6550."
        REFERENCE
            "RFC 6550: RPL: IPv6 Routing Protocol for LLNs"
        ::= { rplStats 13 }

    rplOBitClearedUpwards OBJECT-TYPE
        SYNTAX      Counter32
        MAX-ACCESS  read-only
        STATUS      current
        DESCRIPTION
            "Number of packets received with the 'O' bit cleared
             from a node with a lower rank as defined in Section 18.3.2
             of RFC 6550."
        REFERENCE
            "RFC 6550: RPL: IPv6 Routing Protocol for LLNs"
        ::= { rplStats 14 }

    rplFBitSet OBJECT-TYPE
        SYNTAX      Counter32
        MAX-ACCESS  read-only
        STATUS      current
        DESCRIPTION
            "Number of packets received with the 'F' bit set as
             defined in Section 18.3.2 of RFC 6550."
        REFERENCE
            "RFC 6550: RPL: IPv6 Routing Protocol for LLNs"
```



```
        ::= { rplStats 15 }

    rplRBitSet OBJECT-TYPE
        SYNTAX      Counter32
        MAX-ACCESS  read-only
```

```
        STATUS      current
        DESCRIPTION
            "Number of packets received with the 'R' bit set as
             defined in Section 18.3.2 of RFC 6550."
        REFERENCE
            "RFC 6550: RPL: IPv6 Routing Protocol for LLNs"
        ::= { rplStats 16 }

    rplTrickleTimerResets OBJECT-TYPE
        SYNTAX      Counter32
        MAX-ACCESS  read-only
        STATUS      current
        DESCRIPTION
            "The number of trickle timer resets."
        ::= { rplStats 17 }

    rplMsgStatsTable OBJECT-TYPE
        SYNTAX      SEQUENCE OF RplMsgStatsEntry
        MAX-ACCESS  not-accessible
        STATUS      current
        DESCRIPTION
            "Basic RPL message statistics by message type."
        ::= { rplObjects 10 }

    rplMsgStatsEntry OBJECT-TYPE
        SYNTAX      RplMsgStatsEntry
        MAX-ACCESS  not-accessible
        STATUS      current
        DESCRIPTION
            "Statistics for a specific RPL message type."
        INDEX { rplMsgStatsType }
        ::= { rplMsgStatsTable 1 }

    RplMsgStatsEntry ::= SEQUENCE {
        rplMsgStatsType    RplMessageType,
        rplMsgStatsInMsgs  Counter32,
        rplMsgStatsOutMsgs Counter32
    }

    rplMsgStatsType OBJECT-TYPE
        SYNTAX      RplMessageType
        MAX-ACCESS  not-accessible
        STATUS      current
```

```
    DESCRIPTION
        "The RPL message type being counted by this row."
    ::= { rplMsgStatsEntry 1 }

rplMsgStatsInMsgs OBJECT-TYPE
    SYNTAX      Counter32
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The number of RPL messages received of this type."
    ::= { rplMsgStatsEntry 2 }

rplMsgStatsOutMsgs OBJECT-TYPE
    SYNTAX      Counter32
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The number of RPL messages sent of this type."
    ::= { rplMsgStatsEntry 3 }

-- conformance definitions

rplGroups      OBJECT IDENTIFIER ::= { rplConformance 1 }
rplCompliances OBJECT IDENTIFIER ::= { rplConformance 2 }

rplFullCompliance MODULE-COMPLIANCE
    STATUS      current
    DESCRIPTION
        "Compliance statement for implementations supporting
         read/write access, according to the object definitions."
    MODULE      -- this module
    MANDATORY-GROUPS {
        rplGeneralGroup,
        rplInstanceGroup,
        rplStatsGroup
    }
    ::= { rplCompliances 1 }

rplReadOnlyCompliance MODULE-COMPLIANCE
    STATUS      current
    DESCRIPTION
        "Compliance statement for implementations supporting
         only readonly access."
    MODULE      -- this module
    MANDATORY-GROUPS {
        rplGeneralGroup,
        rplInstanceGroup,
        rplStatsGroup
```

```
    }

    OBJECT rplDefaultDISMode
    MIN-ACCESS  read-only
    DESCRIPTION
        "Write access is not required."

    OBJECT rplActiveInstance
    MIN-ACCESS  read-only
    DESCRIPTION
        "Write access is not required."

    OBJECT rplActiveDodag
    MIN-ACCESS  read-only
    DESCRIPTION
        "Write access is not required."

    OBJECT rplActiveDodagTriggerSequence
    MIN-ACCESS  read-only
    DESCRIPTION
        "Write access is not required."

    OBJECT rplOCPEnabled
    MIN-ACCESS  read-only
    DESCRIPTION
        "Write access is not required."

    OBJECT rplInstanceOCP
    MIN-ACCESS  read-only
    DESCRIPTION
        "Write access is not required."

    OBJECT rplInstanceDisMode
    MIN-ACCESS  read-only
    DESCRIPTION
        "Write access is not required."

    OBJECT rplInstanceDAOAckEnabled
    MIN-ACCESS  read-only
    DESCRIPTION
        "Write access is not required."
```

```
      OBJECT rplInstanceModeOfOperation
      MIN-ACCESS  read-only
      DESCRIPTION
          "Write access is not required."

      OBJECT rplDodagIntervalDoublings
```



```
      MIN-ACCESS  read-only
      DESCRIPTION
          "Write access is not required."

      OBJECT rplDodagIntervalMin
      MIN-ACCESS  read-only
      DESCRIPTION
          "Write access is not required."

      OBJECT rplDodagRedundancyConstant
      MIN-ACCESS  read-only
      DESCRIPTION
          "Write access is not required."

      ::= { rplCompliances 2 }

  rplGeneralGroup OBJECT-GROUP
      OBJECTS {
          rplDefaultDISMode,
          rplActiveInstance,
          rplActiveDodag,
          rplActiveDodagDAOSequence,
          rplActiveDodagTriggerSequence,
          -- rplOCPCodepoint,
          rplOCPEnabled
      }
      STATUS      current
      DESCRIPTION
          "A collection of objects providing general information about
           the RPL implementation."
      ::= { rplGroups 1 }

  rplInstanceGroup OBJECT-GROUP
      OBJECTS {
          -- rplInstanceID,
```

```
            rplInstanceOCP,
            rplInstanceDisMode,
            rplInstanceDAOAckEnabled,
            rplInstanceModeOfOperation,
            -- rplDodagRoot,
            rplDodagVersion,
            rplDodagRank,
            rplDodagState,
            rplDodagDAODelay,
            rplDodagPreference,
            rplDodagMinHopRankIncrease,
            rplDodagMaxRankIncrease,
            rplDodagIntervalDoublings,
```



```
            rplDodagIntervalMin,
            rplDodagRedundancyConstant,
            rplDodagPathControlSize,
            -- rplDodagParentID,
            rplDodagParentIf,
            rplDodagChildID,
            rplDodagPrefixIpv6Prefix,
            rplDodagPrefixIpv6PrefixLength
        }
        STATUS      current
        DESCRIPTION
            "A collection of objects providing insight into the RPL
             Instances and the DODAGs."
        ::= { rplGroups 2 }

    rplStatsGroup OBJECT-GROUP
        OBJECTS {
            rplMemOverflows,
            rplParseErrors,
            rplUnknownMsgTypes,
            rplSecurityPolicyViolations,
            rplIntegrityCheckFailures,
            rplReplayProtectionFailures,
            rplValidParentFailures,
            rplNoInstanceIDs,
            rplTriggeredLocalRepairs,
            rplTriggeredGlobalRepairs,
            rplNoParentSecs,
```

```
            rplActiveNoParentSecs,
            rplOBitSetDownwards,
            rplOBitClearedUpwards,
            rplFBitSet,
            rplRBitSet,
            rplTrickleTimerResets,
            -- rplMsgStatsType,
            rplMsgStatsInMsgs,
            rplMsgStatsOutMsgs
        }
        STATUS      current
        DESCRIPTION
            "A collection of objects providing statistics about the
             RPL implementation."
        ::= { rplGroups 3 }

    END
```


7. Security Considerations

There are a number of management objects defined in this MIB module with a MAX-ACCESS clause of read-write and/or read-create. Such objects may be considered sensitive or vulnerable in some network environments. The support for SET operations in a non-secure environment without proper protection can have a negative effect on network operations. These are the tables and objects and their sensitivity/vulnerability:

o rplActiveInstance: [TBD] explain sensitivity

Some of the readable objects in this MIB module (i.e., objects with a MAX-ACCESS other than not-accessible) may be considered sensitive or vulnerable in some network environments. It is thus important to control even GET and/or NOTIFY access to these objects and possibly to even encrypt the values of these objects when sending them over the network via SNMP. These are the tables and objects and their sensitivity/vulnerability:

[TODO: Need to describe vulnerabilities here.]

SNMP versions prior to SNMPv3 did not include adequate security. Even if the network itself is secure (for example by using IPsec), even then, there is no control as to who on the secure network is allowed to access and GET/SET (read/change/create/delete) the objects in this MIB module.

It is RECOMMENDED that implementers consider the security features as provided by the SNMPv3 framework (see [RFC3410], section 8), including full support for the SNMPv3 cryptographic mechanisms (for authentication and privacy).

Further, deployment of SNMP versions prior to SNMPv3 is NOT RECOMMENDED. Instead, it is RECOMMENDED to deploy SNMPv3 and to enable cryptographic security. It is then a customer/operator responsibility to ensure that the SNMP entity giving access to an instance of this MIB module is properly configured to give access to the objects only to those principals (users) that have legitimate rights to indeed GET or SET (change/create/delete) them.

8. IANA Considerations

IANA is requested to assign a value for "XXXX" under the 'mib-2' subtree and to record the assignment in the SMI Numbers registry. When the assignment has been made, the RFC Editor is asked to replace "XXXX" (here and in the MIB module) with the assigned value and to remove this note.

IANA has allocated a number for RPL in the IANAipRouteProtocol textual convention of the IANA-RTPROTO-MIB.

9. Acknowledgements

The authors like to thank Michael Richardson for providing helpful comments during the development of this specification.

10. References

10.1. Normative References

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10.2. Informative References

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[I-D.ietf-netmod-smi-yang] Schoenwaelder, J., "Translation of SMIv2 MIB Modules to YANG Modules", draft-ietf-netmod-smi-yang-05 (work in progress), April 2012.

[I-D.lhotka-yang-json] Lhotka, L., "Modeling JSON Text with YANG", draft-lhotka-yang-json-01 (work in progress), June 2012.

Appendix A. JSON Representation

Using the translation algorithm defined in [I-D.ietf-netmod-smi-yang], the SMIv2 module can be translated to YANG. Using the JSON representation of data modeled in YANG defined in [I-D.lhotka-yang-json], the objects defined in the MIB module can be represented in JSON as shown below. The compact representation without any white space uses XXXX octets. (Of course, this number depends on the number of octets needed for the counter values.)

```
{
    "RPL-MIB:RPL-MIB": {
        "rplGeneral": {
            "rplDefaultDISMode": "silent"
        },
        "rplActive": {
            "rplActiveInstance": 0,
            "rplActiveDodag": "2001:db8:bad:cafe::1",
            "rplActiveDodagDAOSequence": 42,
            "rplActiveDodagTriggerSequence": 4
        },
        "rplStats": {
            "rplMemOverflows": 0,
            "rplParseErrors": 0,
            "rplUnknownMsgTypes": 1,
            "rplSecurityPolicyViolations": 0,
```

```
    "rplIntegrityCheckFailures": 0,
    "rplReplayProtectionFailures": 0,
    "rplValidParentFailures": 1,
    "rplNoInstanceIDs": 0,
    "rplTriggeredLocalRepairs": 3,
    "rplTriggeredGlobalRepairs": 0,
    "rplNoParentSecs": 15,
    "rplActiveNoParentSecs": 0,
    "rplOBitSetDownwards": 0,
    "rplOBitClearedUpwards": 0,
    "rplFBitSet": 0,
    "rplRBitSet": 0,
    "rplTrickleTimerResets": 42
},
"rplOCPTable": {
    "rplOCPEntry": [
        {
            "rplOCPCodepoint": 0,
            "rplOCPEnabled": true
        }
    ]
},
"rplInstanceTable": {
    "rplInstanceEntry": [
        {
            "rplInstanceID": 0,
            "rplInstanceOCP": 0,
            "rplInstanceDisMode": "send",
            "rplInstanceDAOAckEnabled": false,
            "rplInstanceModeOfOperation":
                 "storingWithoutMulticastSupport"
        }
    ]
},
"rplDodagTable": {
    "rplDodagEntry": [
        {
            "rplInstanceID": 0,
            "rplDodagRoot": "2001:db8:bad:cafe::1",
            "rplDodagVersion": 3,
            "rplDodagRank": 2,
            "rplDodagState": "grounded",
            "rplDodagDAODelay": 1000,
            "rplDodagPreference": 0,
            "rplDodagMinHopRankIncrease": 256,
            "rplDodagMaxRankIncrease": 0,
            "rplDodagIntervalDoublings": 20,
            "rplDodagIntervalMin": 3,
```

```
                    "rplDodagRedundancyConstant": 10,
                    "rplDodagPathControlSize": 0
                }
            ]
        },
        "rplDodagParentTable": {
             "rplDodagParentEntry": [
                 {
                     "rplRPLInstanceID": 0,
                     "rplDodagRoot": "2001:db8:bad:cafe::1",
                     "rplDodagParentID": "2001:db8:bad:cafe::8",
                     "rplDodagParentIf": 1
                 }
             ]
        },
        "rplDodagChildTable": {
            "rplDodagChildEntry": [
                {
                    "rplRPLInstanceID": 0,
                    "rplDodagRoot": "2001:db8:bad:cafe::1",
                    "rplDodagChildID": "2001:db8:bad:cafe::a"
                },
                {
                    "rplRPLInstanceID": 0,
                    "rplDodagRoot": "2001:db8:bad:cafe::1",
                    "rplDodagChildID": "2001:db8:bad:cafe::b"
                }
            ]
        },
        "rplDodagPrefixTable": {
            "rplDodagPrefixEntry": [
                {
                    "rplRPLInstanceID": 0,
                    "rplDodagRoot": "2001:db8:bad:cafe::1",
                    "rplDodagPrefixIpv6Prefix": "2001:db8:bad:cafe::",
                    "rplDodagPrefixIpv6PrefixLength": "64"
                }
            ]
        },
        "rplMsgStatsTable": {
            "rplMsgStatsEntry": [
                {
                    "rplMsgStatsType": 0,
```

```
                    "rplMsgStatsInMsgs": 78,
                    "rplMsgStatsOutMsgs": 23
                },
                {
                    "rplMsgStatsType": 1,
```



```
                    "rplMsgStatsInMsgs": 11,
                    "rplMsgStatsOutMsgs": 54
                },
                {
                    "rplMsgStatsType": 2,
                    "rplMsgStatsInMsgs": 87,
                    "rplMsgStatsOutMsgs": 28
                },
                {
                    "rplMsgStatsType": 4,
                    "rplMsgStatsInMsgs": 47,
                    "rplMsgStatsOutMsgs": 38
                }
            ]
        }
    }
}
```


Appendix B. Open Issues

Should we model objective functions, e.g. by introducing a table that includes things such as MinHopRankIncrease and MaxRankIncrease

Authors' Addresses

Kevin Korte
Jacobs University
Campus Ring 1
Bremen 28759
Germany

EMail: k.korte@jacobs-university.de

Juergen Schoenwaelder

Jacobs University
Campus Ring 1
Bremen 28759
Germany

EMail: j.schoenwaelder@jacobs-university.de

Anuj Sehgal
Jacobs University
Campus Ring 1
Bremen 28759
Germany

EMail: s.anuj@jacobs-university.de

Tina Tsou
Huawei Technologies (USA)
2330 Central Expressway
Santa Clara CA 95050
USA

EMail: tina.tsou.zouting@huawei.com

Cathy Zhou
Huawei Technologies
Bantian, Longgang District
Shenzhen 518129
P.R. China

EMail: cathyzhou@huawei.com