Common YANG Data Types
draft-ietf-netmod-rfc6991-bis-01

Abstract

This document introduces a collection of common data types to be used with the YANG data modeling language. This document obsoletes RFC 6991.

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1. Introduction

YANG [RFC7950] is a data modeling language used to model configuration and state data manipulated by the Network Configuration Protocol (NETCONF) [RFC6241]. The YANG language supports a small set of built-in data types and provides mechanisms to derive other types from the built-in types.

This document introduces a collection of common data types derived from the built-in YANG data types. The derived types are designed to be applicable for modeling all areas of management information. The definitions are organized in several YANG modules. The "ietf-yang-types" module contains generally useful data types. The "ietf-inet-types" module contains definitions that are relevant for the Internet protocol suite.

This document adds new type definitions to the YANG modules and obsoletes [RFC6991]. For further details, see the revision statements of the YANG modules in Section 3 and Section 4 and the summary in Appendix A.

This document uses the YANG terminology defined in Section 3 of [RFC7950].

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "NOT RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in BCP 14 [RFC2119] [RFC8174] when, and only when, they appear in all capitals, as shown here.
2. Overview

This section provides a short overview of the types defined in subsequent sections and their equivalent Structure of Management Information Version 2 (SMIv2) [RFC2578][RFC2579] data types. A YANG data type is equivalent to an SMIv2 data type if the data types have the same set of values and the semantics of the values are equivalent.

Table 1 lists the types defined in the ietf-yang-types YANG module and the corresponding SMIv2 types (- indicates there is no corresponding SMIv2 type).

<table>
<thead>
<tr>
<th>YANG type</th>
<th>Equivalent SMIv2 type (module)</th>
</tr>
</thead>
<tbody>
<tr>
<td>counter32</td>
<td>Counter32 (SNMPv2-SMI)</td>
</tr>
<tr>
<td>zero-based-counter32</td>
<td>ZeroBasedCounter32 (RMON2-MIB)</td>
</tr>
<tr>
<td>counter64</td>
<td>Counter64 (SNMPv2-SMI)</td>
</tr>
<tr>
<td>zero-based-counter64</td>
<td>ZeroBasedCounter64 (HCNUM-TC)</td>
</tr>
<tr>
<td>gauge32</td>
<td>Gauge32 (SNMPv2-SMI)</td>
</tr>
<tr>
<td>gauge64</td>
<td>CounterBasedGauge64 (HCNUM-TC)</td>
</tr>
<tr>
<td>object-identifier</td>
<td>-</td>
</tr>
<tr>
<td>object-identifier-128</td>
<td>OBJECT IDENTIFIER</td>
</tr>
<tr>
<td>date-and-time</td>
<td>-</td>
</tr>
<tr>
<td>date</td>
<td>-</td>
</tr>
<tr>
<td>time</td>
<td>-</td>
</tr>
<tr>
<td>hours</td>
<td>-</td>
</tr>
<tr>
<td>minutes</td>
<td>-</td>
</tr>
<tr>
<td>seconds</td>
<td>-</td>
</tr>
<tr>
<td>centiseconds</td>
<td>-</td>
</tr>
<tr>
<td>milliseconds</td>
<td>-</td>
</tr>
<tr>
<td>microseconds</td>
<td>-</td>
</tr>
<tr>
<td>nanoseconds</td>
<td>-</td>
</tr>
<tr>
<td>timeticks</td>
<td>TimeTicks (SNMPv2-SMI)</td>
</tr>
<tr>
<td>timestamp</td>
<td>TimeStamp (SNMPv2-TC)</td>
</tr>
<tr>
<td>phys-address</td>
<td>PhysAddress (SNMPv2-TC)</td>
</tr>
<tr>
<td>mac-address</td>
<td>MacAddress (SNMPv2-TC)</td>
</tr>
<tr>
<td>xpath1.0</td>
<td>-</td>
</tr>
<tr>
<td>hex-string</td>
<td>-</td>
</tr>
<tr>
<td>uuid</td>
<td>-</td>
</tr>
<tr>
<td>dotted-quad</td>
<td>-</td>
</tr>
<tr>
<td>yang-identifier</td>
<td>-</td>
</tr>
<tr>
<td>revision-identifier</td>
<td>-</td>
</tr>
<tr>
<td>node-instance-identifier</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 1: ietf-yang-types
Table 2 lists the types defined in the ietf-inet-types YANG module and the corresponding SMIv2 types (if any).

<table>
<thead>
<tr>
<th>YANG type</th>
<th>Equivalent SMIv2 type (module)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ip-version</td>
<td>InetVersion (INET-ADDRESS-MIB)</td>
</tr>
<tr>
<td>dscp</td>
<td>Dscp (DIFFSERV-DSCP-TC)</td>
</tr>
<tr>
<td>ipv6-flow-label</td>
<td>IPv6FlowLabel (IPV6-FLOW-LABEL-MIB)</td>
</tr>
<tr>
<td>port-number</td>
<td>InetPortNumber (INET-ADDRESS-MIB)</td>
</tr>
<tr>
<td>as-number</td>
<td>InetAutonomousSystemNumber (INET-ADDRESS-MIB)</td>
</tr>
<tr>
<td>ip-address</td>
<td>-</td>
</tr>
<tr>
<td>ipv4-address</td>
<td>-</td>
</tr>
<tr>
<td>ipv6-address</td>
<td>-</td>
</tr>
<tr>
<td>ip-address-no-zone</td>
<td>-</td>
</tr>
<tr>
<td>ipv4-address-no-zone</td>
<td>-</td>
</tr>
<tr>
<td>ipv6-address-no-zone</td>
<td>-</td>
</tr>
<tr>
<td>ip-prefix</td>
<td>-</td>
</tr>
<tr>
<td>ipv4-prefix</td>
<td>-</td>
</tr>
<tr>
<td>ipv6-prefix</td>
<td>-</td>
</tr>
<tr>
<td>domain-name</td>
<td>-</td>
</tr>
<tr>
<td>host</td>
<td>-</td>
</tr>
<tr>
<td>uri</td>
<td>Uri (URI-TC-MIB)</td>
</tr>
<tr>
<td>email-address</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 2: ietf-inet-types
3. Core YANG Derived Types

The ietf-yang-types YANG module references [IEEE802], [ISO9834-1], [RFC2578], [RFC2579], [RFC2856], [RFC3339], [RFC4122], [RFC4502], [RFC5322], [RFC7950], [XPATH], and [XSD-TYPES].

<CODE BEGINS> file "ietf-yang-types@2019-07-21.yang"

module ietf-yang-types {

  namespace "urn:ietf:params:xml:ns:yang:ietf-yang-types";
  prefix "yang";

  organization
    "IETF Network Modeling (NETMOD) Working Group";

  contact
    "WG Web:  <https://datatracker.ietf.org/wg/netmod/>
    WG List:  <mailto:netmod@ietf.org>
    Editor: Juergen Schoenwaelder
             <mailto:j.schoenwaelder@jacobs-university.de>";

  description
    "This module contains a collection of generally useful derived
    YANG data types.

    The key words 'MUST', 'MUST NOT', 'REQUIRED', 'SHALL', 'SHALL
    NOT', 'SHOULD', 'SHOULD NOT', 'RECOMMENDED', 'NOT RECOMMENDED',
    'MAY', and 'OPTIONAL' in this document are to be interpreted as
    described in BCP 14 (RFC 2119) (RFC 8174) when, and only when,
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    (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 2019-07-21 {

    description

"Schoenwaelder Expires January 22, 2020 [Page 6]"
This revision adds the following new data types:
- date, time
- hours, minutes, seconds
- centiseconds, milliseconds, microseconds, nanoseconds
- revision-identifier, node-instance-identifier

reference
"RFC XXXX: Common YANG Data Types"

revision 2013-07-15 {
  description
  "This revision adds the following new data types:
  - yang-identifier
  - hex-string
  - uuid
  - dotted-quad"
  reference
  "RFC 6991: Common YANG Data Types"
}

revision 2010-09-24 {
  description
  "Initial revision."
  reference
  "RFC 6021: Common YANG Data Types"
}

/*** collection of counter and gauge types ***/

typedef counter32 {
  type uint32;
  description
  "The counter32 type represents a non-negative integer
  that monotonically increases until it reaches a
  maximum value of 2^32-1 (4294967295 decimal), when it
  wraps around and starts increasing again from zero.

  Counters have no defined 'initial' value, and thus, a
  single value of a counter has (in general) no information
  content. Discontinuities in the monotonically increasing
  value normally occur at re-initialization of the
  management system, and at other times as specified in the
  description of a schema node using this type. If such
  other times can occur, for example, the instantiation of
  a schema node of type counter32 at times other than
  re-initialization, then a corresponding schema node
  should be defined, with an appropriate type, to indicate
  the last discontinuity."
The counter32 type should not be used for configuration schema nodes. A default statement SHOULD NOT be used in combination with the type counter32.

In the value set and its semantics, this type is equivalent to the Counter32 type of the SMIv2."
reference
"RFC 2578: Structure of Management Information Version 2 (SMIv2)"
}
typedef zero-based-counter32 {
type yang:counter32;
default "0";
description
"The zero-based-counter32 type represents a counter32 that has the defined ‘initial’ value zero.

A schema node instance of this type will be set to zero (0) on creation and will thereafter increase monotonically until it reaches a maximum value of $2^{32}-1$ (4294967295 decimal), when it wraps around and starts increasing again from zero.

Provided that an application discovers a new schema node instance of this type within the minimum time to wrap, it can use the ‘initial’ value as a delta. It is important for a management station to be aware of this minimum time and the actual time between polls, and to discard data if the actual time is too long or there is no defined minimum time.

In the value set and its semantics, this type is equivalent to the ZeroBasedCounter32 textual convention of the SMIv2."
reference
"RFC 4502: Remote Network Monitoring Management Information Base Version 2"
}
typedef counter64 {
type uint64;
description
"The counter64 type represents a non-negative integer that monotonically increases until it reaches a maximum value of $2^{64}-1$ (18446744073709551615 decimal), when it wraps around and starts increasing again from zero.

Counters have no defined ‘initial’ value, and thus, a single value of a counter has (in general) no information content. Discontinuities in the monotonically increasing
value normally occur at re-initialization of the management system, and at other times as specified in the description of a schema node using this type. If such other times can occur, for example, the instantiation of a schema node of type counter64 at times other than re-initialization, then a corresponding schema node should be defined, with an appropriate type, to indicate the last discontinuity.

The counter64 type should not be used for configuration schema nodes. A default statement SHOULD NOT be used in combination with the type counter64.

In the value set and its semantics, this type is equivalent to the Counter64 type of the SMIv2.

"RFC 2578: Structure of Management Information Version 2 (SMIv2)"

typedef zero-based-counter64 {
type yang:counter64;
default "0";
description
"The zero-based-counter64 type represents a counter64 that has the defined ‘initial’ value zero.

A schema node instance of this type will be set to zero (0) on creation and will thereafter increase monotonically until it reaches a maximum value of $2^{64}-1$ (18446744073709551615 decimal), when it wraps around and starts increasing again from zero.

Provided that an application discovers a new schema node instance of this type within the minimum time to wrap, it can use the ‘initial’ value as a delta. It is important for a management station to be aware of this minimum time and the actual time between polls, and to discard data if the actual time is too long or there is no defined minimum time.

In the value set and its semantics, this type is equivalent to the ZeroBasedCounter64 textual convention of the SMIv2."

"RFC 2856: Textual Conventions for Additional High Capacity Data Types"
}

typedef gauge32 {
type uint32;
description
"The gauge32 type represents a non-negative integer, which
may increase or decrease, but shall never exceed a maximum
value, nor fall below a minimum value. The maximum value
cannot be greater than $2^{32}-1$ (4294967295 decimal), and
the minimum value cannot be smaller than 0. The value of
a gauge32 has its maximum value whenever the information
being modeled is greater than or equal to its maximum
value, and has its minimum value whenever the information
being modeled is smaller than or equal to its minimum value.
If the information being modeled subsequently decreases
below (increases above) the maximum (minimum) value, the
gauge32 also decreases (increases).

In the value set and its semantics, this type is equivalent
to the Gauge32 type of the SMIv2.";
reference
"RFC 2578: Structure of Management Information Version 2
(SMIv2)";
}

typedef gauge64 {
type uint64;
description
"The gauge64 type represents a non-negative integer, which
may increase or decrease, but shall never exceed a maximum
value, nor fall below a minimum value. The maximum value
cannot be greater than $2^{64}-1$ (18446744073709551615), and
the minimum value cannot be smaller than 0. The value of
a gauge64 has its maximum value whenever the information
being modeled is greater than or equal to its maximum
value, and has its minimum value whenever the information
being modeled is smaller than or equal to its minimum value.
If the information being modeled subsequently decreases
below (increases above) the maximum (minimum) value, the
gauge64 also decreases (increases).

In the value set and its semantics, this type is equivalent
to the CounterBasedGauge64 SMIv2 textual convention defined
in RFC 2856";
reference
"RFC 2856: Textual Conventions for Additional High Capacity
Data Types";
}

/*** collection of identifier-related types ***/
typedef object-identifier {
  type string {
    pattern '(([0-1]\.[1-3]?[0-9])|(2\.(0|[1-9]\d*)))' + '(.0|([1-9]\d*))' *;
  }
}

description
"The object-identifier type represents administratively assigned names in a registration-hierarchical-name tree.

Values of this type are denoted as a sequence of numerical non-negative sub-identifier values. Each sub-identifier value MUST NOT exceed 2^32-1 (4294967295). Sub-identifiers are separated by single dots and without any intermediate whitespace.

The ASN.1 standard restricts the value space of the first sub-identifier to 0, 1, or 2. Furthermore, the value space of the second sub-identifier is restricted to the range 0 to 39 if the first sub-identifier is 0 or 1. Finally, the ASN.1 standard requires that an object identifier has always at least two sub-identifiers. The pattern captures these restrictions.

Although the number of sub-identifiers is not limited, module designers should realize that there may be implementations that stick with the SMIv2 limit of 128 sub-identifiers.

This type is a superset of the SMIv2 OBJECT IDENTIFIER type since it is not restricted to 128 sub-identifiers. Hence, this type SHOULD NOT be used to represent the SMIv2 OBJECT IDENTIFIER type; the object-identifier-128 type SHOULD be used instead."

reference
"ISO9834-1: Information technology -- Open Systems Interconnection -- Procedures for the operation of OSI Registration Authorities: General procedures and top arcs of the ASN.1 Object Identifier tree";

typedef object-identifier-128 {
  type object-identifier {
    pattern '\d*\.\d*\{1,127\}';
  }
}

description
"This type represents object-identifiers restricted to 128 sub-identifiers."
In the value set and its semantics, this type is equivalent to the OBJECT IDENTIFIER type of the SMIv2.

"RFC 2578: Structure of Management Information Version 2 (SMIv2)"

/*** collection of types related to date and time ***/

typedef date-and-time {
    type string {
        pattern '\d{4}-\d{2}-\d{2}T\d{2}:\d{2}:\d{2}(\d+)?' + '(Z|\[\+\-\]d{2}:d{2})';
    }

description
"The date-and-time type is a profile of the ISO 8601 standard for representation of dates and times using the Gregorian calendar. The profile is defined by the date-time production in Section 5.6 of RFC 3339.

The date-and-time type is compatible with the dateTime XML schema type with the following notable exceptions:

(a) The date-and-time type does not allow negative years.

(b) The date-and-time time-offset -00:00 indicates an unknown time zone (see RFC 3339) while -00:00 and +00:00 and Z all represent the same time zone in dateTime.

(c) The canonical format (see below) of date-and-time values differs from the canonical format used by the dateTime XML schema type, which requires all times to be in UTC using the time-offset 'Z'.

This type is not equivalent to the DateAndTime textual convention of the SMIv2 since RFC 3339 uses a different separator between full-date and full-time and provides higher resolution of time-secfrac.

The canonical format for date-and-time values with a known time zone uses a numeric time zone offset that is calculated using the device's configured known offset to UTC time. A change of the device’s offset to UTC time will cause date-and-time values to change accordingly. Such changes might happen periodically in case a server follows automatically daylight saving time (DST) time zone offset changes. The canonical format for date-and-time values with an unknown time zone (usually referring to the notion of local time) uses the time-offset
typedef date {
    type string {
        pattern '\d{4}-\d{2}-\d{2}'
        + '([0-9][-][0-9])';
    }
    description
        "The date type represents a time-interval of the length
        of a day, i.e., 24 hours.

        The date type is compatible with the date XML schema
        type with the following notable exceptions:

        (a) The date type does not allow negative years.

        (b) The date time-offset -00:00 indicates an unknown
            time zone (see RFC 3339) while -00:00 and +00:00 and Z
            all represent the same time zone in date.

        (c) The canonical format (see below) of data values
            differs from the canonical format used by the date XML
            schema type, which requires all times to be in UTC using
            the time-offset 'Z'.

        The canonical format for date values with a known time
        zone uses a numeric time zone offset that is calculated using
        the device’s configured known offset to UTC time. A change of
        the device’s offset to UTC time will cause date values
        to change accordingly. Such changes might happen periodically
        in case a server follows automatically daylight saving time
        (DST) time zone offset changes. The canonical format for
        date values with an unknown time zone (usually referring
        to the notion of local time) uses the time-offset -00:00.";
    reference
        "RFC 3339: Date and Time on the Internet: Timestamps
}

/* DISCUSS:
   - XML schema seems to use a different canonical format, we
     need to take a closer look how to define the canonical format

Schoenwaelder            Expires January 22, 2020       [Page 13]
* given that a data really identifies a 24 hour interval and
* what XSD means with 'interval midpoint'.
*/

typedef time {
    type string {
        pattern '\d{2}:\d{2}:\d{2}(.\d+)?'
        + '(Z|\[\+\-]\d{2}:\d{2})';
    }
    description
    "The time type represents an instance of time of zero-duration
    that recurs every day.

    The time type is compatible with the time XML schema
type with the following notable exceptions:

    (a) The time time-offset -00:00 indicates an unknown
time zone (see RFC 3339) while -00:00 and +00:00 and Z
all represent the same time zone in time.

    (c) The canonical format (see below) of time values
differs from the canonical format used by the time XML
schema type, which requires all times to be in UTC using
the time-offset 'Z'.

    The canonical format for time values with a known time
zone uses a numeric time zone offset that is calculated using
the device’s configured known offset to UTC time. A change of
the device’s offset to UTC time will cause time values
to change accordingly. Such changes might happen periodically
in case a server follows automatically daylight saving time
(DST) time zone offset changes. The canonical format for
time values with an unknown time zone (usually referring
to the notion of local time) uses the time-offset -00:00.";
    reference
    "RFC 3339: Date and Time on the Internet: Timestamps
}

typedef hours {
    type uint32;
    units "hours";
    description
    "A period of time, measured in units of hours.";
}

typedef minutes {
    type uint32;
}
typedef seconds {
  type uint32;
  units "seconds";
  description
      "A period of time, measured in units of seconds. 
The maximum duration that can be expressed is in the 
order of 49710 days and 6 hours and 28 minutes and 15
seconds.";
}

typedef centiseconds {
  type uint32;
  units "centiseconds";
  description
      "A period of time, measured in units of \(10^{-2}\) seconds. 
The maximum duration that can be expressed is in the 
order of 497 days and 2 hours and 27 minutes and 52
seconds.";
}

typedef milliseconds {
  type uint32;
  units "milliseconds";
  description
      "A period of time, measured in units of \(10^{-3}\) seconds. 
The maximum duration that can be expressed is in the 
order of 49 days and 17 hours and 2 minutes and 47
seconds.";
}

typedef microseconds {
  type uint32;
  units "microseconds";
  description
      "A period of time, measured in units of \(10^{-6}\) seconds. 
The maximum duration that can be expressed is in the 
order of 1 hour and 11 minutes and 34 seconds.";
}

typedef nanoseconds {
  type uint32;
  units "nanoseconds";
  description
      "A period of time, measured in units of \(10^{-9}\) seconds. 
The maximum duration that can be expressed is in the 
order of 1 year and 25 days and 23 hours and 27
minutes and 34 seconds.";
}
"A period of time, measured in units of 10^-9 seconds. The maximum duration that can be expressed is in the order of 4 seconds."

*/

/* DISCUSS:
* - do we need (nano|micro|milli)seconds with 64 bits?
* - do we add typedef timeinterval { type centiseconds
*   { range 0..2147483647 } } for compatibility with SMIv2?
* - some modules use negative minutes, do we care? A _duration_
*   does likely not need negative values. However, if minutes are
*   used to represent a relative time offset, then negative minutes
*   do make sense. Do we have to support durations as well as
*   time offsets?
*/

typedef timeticks {
  type uint32;
  description
  "The timeticks type represents a non-negative integer that represents the time, modulo 2^32 (4294967296 decimal), in hundredths of a second between two epochs. When a schema node is defined that uses this type, the description of the schema node identifies both of the reference epochs.

In the value set and its semantics, this type is equivalent to the TimeTicks type of the SMIv2.";
  reference
  "RFC 2578: Structure of Management Information Version 2 (SMIv2)"
}

typedef timestamp {
  type yang:timeticks;
  description
  "The timestamp type represents the value of an associated timeticks schema node instance at which a specific occurrence happened. The specific occurrence must be defined in the description of any schema node defined using this type. When the specific occurrence occurred prior to the last time the associated timeticks schema node instance was zero, then the timestamp value is zero.

Note that this requires all timestamp values to be reset to zero when the value of the associated timeticks schema node instance reaches 497+ days and wraps around to zero."
The associated timeticks schema node must be specified in the description of any schema node using this type.

In the value set and its semantics, this type is equivalent to the TimeStamp textual convention of the SMIv2.

reference
RFC 2579: Textual Conventions for SMIv2

/*** collection of generic address types ***/

typedef phys-address {
  type string {
    pattern '([0-9a-fA-F]{2}(:[0-9a-fA-F]{2})*)?';
  }
  description
  "Represents media- or physical-level addresses represented as a sequence octets, each octet represented by two hexadecimal numbers. Octets are separated by colons. The canonical representation uses lowercase characters.

  In the value set and its semantics, this type is equivalent to the PhysAddress textual convention of the SMIv2.";
  reference
  RFC 2579: Textual Conventions for SMIv2
}

typedef mac-address {
  type string {
    pattern '[0-9a-fA-F]{2}([0-9a-fA-F]{2}){5}';
  }
  description
  "The mac-address type represents an IEEE 802 MAC address. The canonical representation uses lowercase characters.

  In the value set and its semantics, this type is equivalent to the MacAddress textual convention of the SMIv2.";
  reference
  IEEE 802: IEEE Standard for Local and Metropolitan Area Networks: Overview and Architecture
  RFC 2579: Textual Conventions for SMIv2
}

/*** collection of XML-specific types ***/

typedef xpath1.0 {
  type string;
  description
"This type represents an XPATH 1.0 expression.

When a schema node is defined that uses this type, the description of the schema node MUST specify the XPath context in which the XPath expression is evaluated.";
reference
"XPATH: XML Path Language (XPath) Version 1.0";
}

/*
 * DISCUSS:
 * - How do we deal with xpath expressions in other encodings
 *   such as JSON. Do we assume an xpath context populated with
 *   module names such that module names can be used to qualify
 *   path expressions. This may need discussion and/or a new
 *   definition.
 * - This interacts with the definition of node-instance-identifier.
 */

/*** collection of string types ***/

typedef hex-string {
  type string {
    pattern '([0-9a-fA-F]{2}(:[0-9a-fA-F]{2})*)?';
  }
  description
  "A hexadecimal string with octets represented as hex digits
  separated by colons. The canonical representation uses
  lowercase characters.";
}

typedef uuid {
  type string {
    pattern '([0-9a-fA-F]{8}-[0-9a-fA-F]{4}-[0-9a-fA-F]{4}-'
    + '[0-9a-fA-F]{4}-[0-9a-fA-F]{12}');
  }
  description
  "A Universally Unique IDentifier in the string representation
  defined in RFC 4122. The canonical representation uses
  lowercase characters.

  The following is an example of a UUID in string representation:
f81d4fae-7dec-11d0-a765-00a0c91e6bf6
";
reference
"RFC 4122: A Universally Unique IDentifier (UUID) URN
Namespace";
typedef dotted-quad {
    type string {
        pattern '
    }
    description
        "An unsigned 32-bit number expressed in the dotted-quad
         notation, i.e., four octets written as decimal numbers
         and separated with the '.' (full stop) character.";
}

/*** collection of YANG specific types ***/

typedef yang-identifier {
    type string {
        length "1..max";
        pattern '[a-zA-Z_]\[a-zA-Z0-9\-_.\]*';
        pattern '.\.|\.\.[^xX]\.\.[^mM]\.\.[^lL]\.\.*';
    }
    description
        "A YANG identifier string as defined by the 'identifier'
         rule in Section 12 of RFC 6020. An identifier must
         start with an alphabetic character or an underscore
         followed by an arbitrary sequence of alphabetic or
         numeric characters, underscores, hyphens, or dots.

         A YANG identifier MUST NOT start with any possible
         combination of the lowercase or uppercase character
         sequence 'xml'.";
    reference
        "RFC 6020: YANG - A Data Modeling Language for the Network
         Configuration Protocol (NETCONF)";
}

typedef revision-identifier {
    type date {
        pattern '\d{4}-\d{2}-\d{2}';
    }
    description
        "Represents a specific revision of a YANG module by means of
        a date value without a time zone.";
}

typedef node-instance-identifier {
    type xpath1.0;
    description
        "Path expression used to represent a special
data node, action, or notification instance-identifier string.

A node-instance-identifier value is an unrestricted YANG instance-identifier expression.

All the same rules as an instance-identifier apply, except that predicates for keys are optional. If a key predicate is missing, then the node-instance-identifier represents all possible server instances for that key.

This XML Path Language (XPath) expression is evaluated in the following context:

- The set of namespace declarations are those in scope on the leaf element where this type is used.
- The set of variable bindings contains one variable, 'USER', which contains the name of the user of the current session.
- The function library is the core function library, but note that due to the syntax restrictions of an instance-identifier, no functions are allowed.
- The context node is the root node in the data tree.

The accessible tree includes actions and notifications tied to data nodes.

/*
* DISCUSS:
* - This is taken from RFC 8341 and the idea is that this definition is useful without requiring a dependency on NACM
* - What does the second bullet actually do? Do we keep this?
* - How does this work with JSON? Can we make this encoding neutral (but then we knowingly depart from NACM)?
* - This interacts with the definition of xpath1.0.
*/

/* DISCUSS:
* - It was suggested to add types for longitude, latitude, postal code, country-code. Do we go there or do we leave these for other modules to define? It seems such definitions should go into draft-ietf-netmod-geo-location.
*/
/* DISCUSS:
 * - It was suggested to add percentage types but they tend to differ
 *   widely. However, percentages are also widely used.
 */

<CODE ENDS>
4. Internet-Specific Derived Types

The ietf-inet-types YANG module references [RFC0768], [RFC0791], [RFC0793], [RFC0952], [RFC1034], [RFC1123], [RFC1930], [RFC2460], [RFC2474], [RFC2780], [RFC2782], [RFC3289], [RFC3305], [RFC3595], [RFC3986], [RFC4001], [RFC4007], [RFC4271], [RFC4291], [RFC4340], [RFC4960], [RFC5017], [RFC5890], [RFC5952], and [RFC6793].

<CODE BEGINS> file "ietf-inet-types@2019-07-021.yang"

module ietf-inet-types {
    namespace "urn:ietf:params:xml:ns:yang:ietf-inet-types";
    prefix "inet";

    organization "IETF Network Modeling (NETMOD) Working Group";

    contact "WG Web:  <https://datatracker.ietf.org/wg/netmod/>\n        WG List:  <mailto:netmod@ietf.org>\n                   Editor:  Juergen Schoenwaelder\n                           <mailto:j.schoenwaelder@jacobs-university.de>";

    description "This module contains a collection of generally useful derived
           YANG data types for Internet addresses and related things.

           The key words 'MUST', 'MUST NOT', 'REQUIRED', 'SHALL', 'SHALL NOT',
           'SHOULD', 'SHOULD NOT', 'RECOMMENDED', 'NOT RECOMMENDED',
           'MAY', and 'OPTIONAL' in this document are to be interpreted as
           described in BCP 14 (RFC 2119) (RFC 8174) when, and only when,
           they appear in all capitals, as shown here.

           Copyright (c) 2019 IETF Trust and the persons identified as
           authors of the code.  All rights reserved.

           Redistribution and use in source and binary forms, with or
           without modification, is permitted pursuant to, and subject
           to the license terms contained in, the Simplified BSD License
           set forth in Section 4.c of the IETF Trust’s Legal Provisions
           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.";

<CODE ENDS>
revision 2019-07-21 {
    description
    "This revision adds the following new data types:
    - ip-address-and-prefix
    - ipv4-address-and-prefix
    - ipv6-address-and-prefix
    - email-address";
    reference
    "RFC XXXX: Common YANG Data Types";
}

revision 2013-07-15 {
    description
    "This revision adds the following new data types:
    - ip-address-no-zone
    - ipv4-address-no-zone
    - ipv6-address-no-zone";
    reference
    "RFC 6991: Common YANG Data Types";
}

revision 2010-09-24 {
    description
    "Initial revision.";
    reference
    "RFC 6021: Common YANG Data Types";
}

/*** collection of types related to protocol fields ***/
typedef ip-version {
    type enumeration {
        enum unknown {
            value "0";
            description
            "An unknown or unspecified version of the Internet
            protocol.";
        }
        enum ipv4 {
            value "1";
            description
            "The IPv4 protocol as defined in RFC 791.";
        }
        enum ipv6 {
            value "2";
            description
            "The IPv6 protocol as defined in RFC 2460.";
        }
    }
}
typedef dscp {
  type uint8 {
    range "0..63";
  }
  description
  "The dscp type represents a Differentiated Services Code Point
  that may be used for marking packets in a traffic stream.

  In the value set and its semantics, this type is equivalent
to the Dscp textual convention of the SMIv2.";
  reference
  "RFC 3289: Management Information Base for the Differentiated
   Services Architecture
RFC 2474: Definition of the Differentiated Services Field
   (DS Field) in the IPv4 and IPv6 Headers
RFC 2780: IANA Allocation Guidelines For Values In
   the Internet Protocol and Related Headers";
}

typedef ipv6-flow-label {
  type uint32 {
    range "0..1048575";
  }
  description
  "The ipv6-flow-label type represents the flow identifier or
   Flow Label in an IPv6 packet header that may be used to
discriminate traffic flows.

  In the value set and its semantics, this type is equivalent
to the IPv6FlowLabel textual convention of the SMIv2.";
  reference
  "RFC 3595: Textual Conventions for IPv6 Flow Label
}

typedef port-number {
type uint16 {
    range "0..65535";
}
description
"The port-number type represents a 16-bit port number of an 
Internet transport-layer protocol such as UDP, TCP, DCCP, or 
SCTP. Port numbers are assigned by IANA. A current list of 
all assignments is available from <http://www.iana.org/>.

Note that the port number value zero is reserved by IANA. In 
situations where the value zero does not make sense, it can 
be excluded by subtyping the port-number type.

In the value set and its semantics, this type is equivalent 
to the InetPortNumber textual convention of the SMIv2.";
reference
RFC 768: User Datagram Protocol
RFC 793: Transmission Control Protocol
RFC 4960: Stream Control Transmission Protocol
RFC 4340: Datagram Congestion Control Protocol (DCCP)
RFC 4001: Textual Conventions for Internet Network Addresses"
}

/*** collection of types related to autonomous systems ***/

typedef as-number {
    type uint32;
    description
    "The as-number type represents autonomous system numbers 
which identify an Autonomous System (AS). An AS is a set 
of routers under a single technical administration, using 
an interior gateway protocol and common metrics to route 
packets within the AS, and using an exterior gateway 
protocol to route packets to other ASes. IANA maintains 
the AS number space and has delegated large parts to the 
regional registries.

Autonomous system numbers were originally limited to 16 
bits. BGP extensions have enlarged the autonomous system 
number space to 32 bits. This type therefore uses an uint32 
base type without a range restriction in order to support 
a larger autonomous system number space.

In the value set and its semantics, this type is equivalent 
to the InetAutonomousSystemNumber textual convention of 
the SMIv2.";
reference
"RFC 1930: Guidelines for creation, selection, and registration
typedef ip-address {
  type union {
    type inet:ipv4-address;
    type inet:ipv6-address;
  }
  description
  "The ip-address type represents an IP address and is IP
  version neutral. The format of the textual representation
  implies the IP version. This type supports scoped addresses
  by allowing zone identifiers in the address format.";
  reference
  "RFC 4007: IPv6 Scoped Address Architecture";
}

typedef ipv4-address {
  type string {
    pattern
    '(((0-9)[1-9][0-9]|1[0-9][0-9]|2[0-4][0-9]|25[0-5])\.){3}'
    + '([0-9]|1[0-9][0-9]|2[0-4][0-9]|25[0-5])'
    + '(%[\p{N}\p{L}]?)?';
  }
  description
  "The ipv4-address type represents an IPv4 address in
dotted-quad notation. The IPv4 address may include a zone
index, separated by a % sign.

The zone index is used to disambiguate identical address
values. For link-local addresses, the zone index will
typically be the interface index number or the name of an
interface. If the zone index is not present, the default
zone of the device will be used.

The canonical format for the zone index is the numerical
format";
}

typedef ipv6-address {
  type string {
    pattern
    '((:[0-9a-fA-F]{0,4}]):([0-9a-fA-F]{0,4})):([0-9a-fA-F]{0,4}):
    ([0-9a-fA-F]{0,4})):([0-9a-fA-F]{0,4})):([0-9a-fA-F]{0,4}):
    ([0-9a-fA-F]{0,4})

The zone index is used to disambiguate identical address
values. For link-local addresses, the zone index will
typically be the interface index number or the name of an
interface. If the zone index is not present, the default
zone of the device will be used.

The canonical format for the zone index is the numerical
format";
The `ipv6-address` type represents an IPv6 address in full, mixed, shortened, and shortened-mixed notation. The IPv6 address may include a zone index, separated by a % sign.

The zone index is used to disambiguate identical address values. For link-local addresses, the zone index will typically be the interface index number or the name of an interface. If the zone index is not present, the default zone of the device will be used.

The canonical format of IPv6 addresses uses the textual representation defined in Section 4 of RFC 5952. The canonical format for the zone index is the numerical format as described in Section 11.2 of RFC 4007.

---

**Typedef ip-address-no-zone**

```yang
type union {
  type inet:ipv4-address-no-zone;
  type inet:ipv6-address-no-zone;
}
description
  "The ip-address-no-zone type represents an IP address and is IP version neutral. The format of the textual representation implies the IP version. This type does not support scoped addresses since it does not allow zone identifiers in the address format."
reference
  "RFC 4007: IPv6 Scoped Address Architecture"
}

typedef ipv4-address-no-zone {
  type inet:ipv4-address {
    pattern '[0-9.]*';
}
```
typedef ipv6-address-no-zone {
    type inet:ipv6-address {
        pattern '[0-9a-fA-F:.]*';
    }
}

description
"An IPv6 address without a zone index. This type, derived from
ipv6-address, may be used in situations where the zone is known
from the context and hence no zone index is needed.";

typedef ip-prefix {
    type union {
        type inet:ipv4-prefix;
        type inet:ipv6-prefix;
    }
}

description
"The ip-prefix type represents an IP prefix and is IP
version neutral. The format of the textual representations
implies the IP version.";

typedef ipv4-prefix {
    type string {
        pattern
            '(((0-9)|[1-9][0-9]|1[0-9][0-9]|2[0-4][0-9]|25[0-5])\.){3}'
            + '(((0-9)|[1-9][0-9]|1[0-9][0-9]|2[0-4][0-9]|25[0-5])' + '/((0-9)|([1-2][0-9])|(3[0-2]))';
    }
}

description
"The ipv4-prefix type represents an IPv4 prefix.
The prefix length is given by the number following the
slash character and must be less than or equal to 32.

A prefix length value of n corresponds to an IP address
mask that has n contiguous 1-bits from the most
significant bit (MSB) and all other bits set to 0."
The canonical format of an IPv4 prefix has all bits of the IPv4 address set to zero that are not part of the IPv4 prefix.

The definition of ipv4-prefix does not require that bits, which are not part of the prefix, are set to zero. However, implementations have to return values in canonical format, which requires non-prefix bits to be set to zero. This means that 192.0.2.1/24 must be accepted as a valid value but it will be converted into the canonical format 192.0.2.0/24.

typedef ipv6-prefix {
    type string {
        pattern '((:|[0-9a-fA-F]{0,4}):){0,5}'
        + '(((0-9a-fA-F){0,4}):)?(:[0-9a-fA-F]{0,4})' |
        + '((25[0-5]|2[0-4]\[0-9]|1[01]?[0-9]{0,2})\.[0-9]{0,2}){3}'
        + '25[0-5]|2[0-4]\[0-9]|1[01]?[0-9]{0,2})' |
        + '/(((0-9)|([0-9]{2})([12][0-8])))' |
        + '/((^[^:]+:){6}(([^:]+:)?[^:]+)?[^:]+/.+)/' |
        + '(/(([^:]+:)*[^:]+)?[^:]+/[^:]+/[^:]+)?' |
        + '/.+)/';
    }

description
"The ipv6-prefix type represents an IPv6 prefix. The prefix length is given by the number following the slash character and must be less than or equal to 128.

A prefix length value of n corresponds to an IP address mask that has n contiguous 1-bits from the most significant bit (MSB) and all other bits set to 0.

The canonical format of an IPv6 prefix has all bits of the IPv6 address set to zero that are not part of the IPv6 prefix. Furthermore, the IPv6 address is represented as defined in Section 4 of RFC 5952.

The definition of ipv6-prefix does not require that bits, which are not part of the prefix, are set to zero. However, implementations have to return values in canonical format, which requires non-prefix bits to be set to zero. This means that 2001:db8::1/64 must be accepted as a valid value but it will be converted into the canonical format 2001:db8::/64.";
reference
"RFC 5952: A Recommendation for IPv6 Address Text Representation";
typedef ip-address-and-prefix {
  type union {
    type inet:ipv4-address-and-prefix;
    type inet:ipv6-address-and-prefix;
  }
  description
  "The ip-address-and-prefix type represents an IP address and
  prefix and is IP version neutral. The format of the textual
  representations implies the IP version."
}

typedef ipv4-address-and-prefix {
  type string {
    pattern
      '(((0-9)|[1-9][0-9]|1[0-9][0-9]|2[0-4][0-9]|25[0-5])\.)\{3\}'
      + '(((0-9)|[1-9][0-9]|1[0-9][0-9]|2[0-4][0-9]|25[0-5]))'
      + '/(((0-9)|([1-2][0-9]))\{3\})';
  }
  description
  "The ipv4-address-and-prefix type represents an IPv4
  address and an associated ipv4 prefix.
  The prefix length is given by the number following the
  slash character and must be less than or equal to 32.
  A prefix length value of n corresponds to an IP address
  mask that has n contiguous 1-bits from the most
  significant bit (MSB) and all other bits set to 0.";
}

typedef ipv6-address-and-prefix {
  type string {
    pattern
      '(((0-9)|[1-9][0-9]|1[0-9][0-9]|2[0-4][0-9]|25[0-5])\.)\{3\}'
      + '(((0-9)|[1-9][0-9]|1[0-9][0-9]|2[0-4][0-9]|25[0-5]))'
      + '/(((0-9)|([1-2][0-9]))\{3\})';
      + '([^:]+:){6}(([^:]+:)?::([^:]+:)?|.*\.*))'
      + '(((^[^:]+):[^:]+)?::([^[^:]+][^:]+)?'[\[.*\]*)')
      + '/(.+)';
  }
  description
  "The ipv6-address-and-prefix type represents an IPv6
  address and an associated ipv4 prefix.
  The prefix length is given by the number following the
  slash character and must be less than or equal to 128.
  A prefix length value of n corresponds to an IP address
  mask that has n contiguous 1-bits from the most
  significant bit (MSB) and all other bits set to 0.";
significant bit (MSB) and all other bits set to 0.

The canonical format requires that the IPv6 address is represented as defined in Section 4 of RFC 5952.

reference
"RFC 5952: A Recommendation for IPv6 Address Text Representation"

}/*** collection of domain name and URI types ***/

typedef domain-name {
  type string {
    length "1..253";
    pattern "((a-zA-Z0-9\[\_\])?([a-zA-Z0-9\-\_]\[0,61]\[a-zA-Z0-9\_\])\[0,61]\[a-zA-Z0-9\_\])\[0,61]\[a-zA-Z0-9\_\]?)" | ".";
  }

description
"The domain-name type represents a DNS domain name. The name SHOULD be fully qualified whenever possible.

Internet domain names are only loosely specified. Section 3.5 of RFC 1034 recommends a syntax (modified in Section 2.1 of RFC 1123). The pattern above is intended to allow for current practice in domain name use, and some possible future expansion. It is designed to hold various types of domain names, including names used for A or AAAA records (host names) and other records, such as SRV records. Note that Internet host names have a stricter syntax (described in RFC 952) than the DNS recommendations in RFCs 1034 and 1123, and that systems that want to store host names in schema node instances using the domain-name type are recommended to adhere to this stricter standard to ensure interoperability.

The encoding of DNS names in the DNS protocol is limited to 255 characters. Since the encoding consists of labels prefixed by a length bytes and there is a trailing NULL byte, only 253 characters can appear in the textual dotted notation.

The description clause of schema nodes using the domain-name type MUST describe when and how these names are resolved to IP addresses. Note that the resolution of a domain-name value may require to query multiple DNS records (e.g., A for IPv4 and AAAA for IPv6). The order of the resolution process and
which DNS record takes precedence can either be defined explicitly or may depend on the configuration of the resolver.

Domain-name values use the US-ASCII encoding. Their canonical format uses lowercase US-ASCII characters. Internationalized domain names MUST be A-labels as per RFC 5890.

```
typedef host {
  type union {
    type inet:ip-address;
    type inet:domain-name;
  }
  description
    "The host type represents either an IP address or a DNS domain name."
}
```

```
typedef uri {
  type string;
  description
    "The uri type represents a Uniform Resource Identifier (URI) as defined by STD 66."
}
```

Objects using the uri type MUST be in US-ASCII encoding,
and MUST be normalized as described by RFC 3986 Sections 6.2.1, 6.2.2.1, and 6.2.2.2. All unnecessary percent-encoding is removed, and all case-insensitive characters are set to lowercase except for hexadecimal digits, which are normalized to uppercase as described in Section 6.2.2.1.

The purpose of this normalization is to help provide unique URIs. Note that this normalization is not sufficient to provide uniqueness. Two URIs that are textually distinct after this normalization may still be equivalent.

Objects using the uri type may restrict the schemes that they permit. For example, 'data:' and 'urn:' schemes might not be appropriate.

A zero-length URI is not a valid URI. This can be used to express 'URI absent' where required.

In the value set and its semantics, this type is equivalent to the Uri SMIv2 textual convention defined in RFC 5017."

```
typedef email-address {
  type string {
    // dot-atom-text "@" ...
    pattern '[a-zA-Z0-9!#$%&’"+*/=^_\-]+\.[a-zA-Z0-9!#$%&’"+*/=^_\-]+@'[a-zA-Z0-9!#$%&’"+*/=^_\-]+\.[a-zA-Z0-9!#$%&’"+*/=^_\-]+';
    description "The email-address type represents an email address as defined as addr-spec in RFC 5322 section 3.4.1.";
    reference "RFC 5322: Internet Message Format";
  }
}
```
DISCUSS:

- It was suggested to add email types following RFC 5322
  - email-address        (addr-spec, per Section 3.4.1)
  - named-email-address  (name-addr, per Section 3.4)
- This sounds useful but the devil is in the details,
  - in particular name-addr is a quite complex construct;
  - perhaps addr-spec is sufficient, this is also the
  - format allowed in mailto: URIs (mailto: seems to use
  - only a subset of addr-spec which may be good enough
  - here as well).
- Need to define a pattern that has a meaningful trade-off
  - between precision and complexity (there are very tight
  - pattern that are very long and complex). The current
  - pattern does not take care of quoted-string, obs-local-part,
  - domain-literal, obs-domain.

*/
5. IANA Considerations

This document registers two URIs in the IETF XML registry [RFC3688]. Following the format in RFC 3688, the following registrations have been made.

Registrant Contact: The NETMOD WG of the IETF.
XML: N/A, the requested URI is an XML namespace.

Registrant Contact: The NETMOD WG of the IETF.
XML: N/A, the requested URI is an XML namespace.

This document registers two YANG modules in the YANG Module Names registry [RFC6020].

<table>
<thead>
<tr>
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<th>ietf-yang-types</th>
</tr>
</thead>
<tbody>
<tr>
<td>namespace</td>
<td>urn:ietf:params:xml:ns:yang:ietf-yang-types</td>
</tr>
<tr>
<td>prefix</td>
<td>yang</td>
</tr>
<tr>
<td>reference</td>
<td>RFC XXXX</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>name</th>
<th>ietf-inet-types</th>
</tr>
</thead>
<tbody>
<tr>
<td>namespace</td>
<td>urn:ietf:params:xml:ns:yang:ietf-inet-types</td>
</tr>
<tr>
<td>prefix</td>
<td>inet</td>
</tr>
<tr>
<td>reference</td>
<td>RFC XXXX</td>
</tr>
</tbody>
</table>
6. Security Considerations

This document defines common data types using the YANG data modeling language. The definitions themselves have no security impact on the Internet, but the usage of these definitions in concrete YANG modules might have. The security considerations spelled out in the YANG specification [RFC7950] apply for this document as well.
7. Contributors

The following people contributed significantly to the initial version of this document:

- Andy Bierman (Brocade)
- Martin Bjorklund (Tail-f Systems)
- Balazs Lengyel (Ericsson)
- David Partain (Ericsson)
- Phil Shafer (Juniper Networks)
8. Acknowledgments

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Juergen Schoenwaelder was partly funded by Flamingo, a Network of Excellence project (ICT-318488) supported by the European Commission under its Seventh Framework Programme.
9. References

9.1. Normative References


9.2. Informative References


[XSD-TYPES]
Appendix A. Changes from RFC 6991

This version adds new type definitions to the YANG modules. The following new data types have been added to the ietf-yang-types module:

- date, time
- hours, minutes, seconds
- centiseconds, milliseconds, microseconds, nanoseconds
- revision-identifier, node-instance-identifier

The following new data types have been added to the ietf-inet-types module:

- ip-address-and-prefix, ipv4-address-and-prefix, ipv6-address-and-prefix
- email-address
Appendix B. Changes from RFC 6021

This version adds new type definitions to the YANG modules. The following new data types have been added to the ietf-yang-types module:

- yang-identifier
- hex-string
- uuid
- dotted-quad

The following new data types have been added to the ietf-inet-types module:

- ip-address-no-zone
- ipv4-address-no-zone
- ipv6-address-no-zone
Author’s Address

Juergen Schoenwaelder (editor)
Jacobs University

Email: j.schoenwaelder@jacobs-university.de