A YANG Data Model for NTP

draft-ietf-ntp-yang-data-model-06

Abstract

This document defines a YANG data model for Network Time Protocol (NTP) implementations. The data model includes configuration data and state data.

Requirements Language

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] when, and only when, they appear in all capitals, as shown here.

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1. Introduction


The data model covers configuration of system parameters of NTP, such as access rules, authentication and VPN Routing and Forwarding (VRF) binding, and also associations of NTP in different modes and parameters of per-interface. It also provides information about running state of NTP implementations.

1.1. Operational State

NTP Operational State is included in the same tree as NTP configuration, consistent with Network Management Datastore Architecture [RFC8342]. NTP current state and statistics are also maintained in the operational state. Additionally, the operational state also include the associations state.

1.2. Terminology

The terminology used in this document is aligned to [RFC5905].

1.3. Tree Diagrams

A simplified graphical representation of the data model is used in this document. This document uses the graphical representation of data models defined in [RFC8340].

1.4. Prefixes in Data Node Names

In this document, names of data nodes and other data model objects are often used without a prefix, as long as it is clear from the context in which YANG module each name is defined. Otherwise, names are prefixed using the standard prefix associated with the corresponding YANG module, as shown in Table 1.
1.5. References in the Model

Following documents are referenced in the model defined in this document:

<table>
<thead>
<tr>
<th>Title</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Common YANG Data Types</td>
<td>[RFC6991]</td>
</tr>
<tr>
<td>A YANG Data Model for System Management</td>
<td>[RFC7317]</td>
</tr>
<tr>
<td>YANG Data Model for Key Chains</td>
<td>[RFC8177]</td>
</tr>
<tr>
<td>Common YANG Data Types for the Routing Area</td>
<td>[RFC8294]</td>
</tr>
<tr>
<td>A YANG Data Model for Interface Management</td>
<td>[RFC8343]</td>
</tr>
<tr>
<td>YANG Data Model for Network Access Control Lists (ACLs)</td>
<td>[RFC8519]</td>
</tr>
</tbody>
</table>

Table 2: References in the YANG modules

2. NTP data model

This document defines the YANG module "ietf-ntp", which has the following condensed structure:
module: ietf-ntp
  +--rw ntp!
    +--rw port? inet:port-number {ntp-port}?
    +--rw refclock-master!
      +--rw master-stratum? ntp-stratum
    +--rw authentication
      +--rw auth-enabled? boolean
      +--rw authentication-keys* [key-id]
        +--rw key-id uint32
        +--...
    +--rw access-rules
      +--rw access-rule* [access-mode]
        +--rw access-mode access-mode
        +--rw acl? -> /acl:acls/acl/name
    +--ro clock-state
      +--ro system-status
      +--ro clock-state ntp-clock-status
      +--ro clock-stratum ntp-stratum
      +--ro clock-refid union
      +--...
    +--rw unicast-configuration* [address type]
      +--rw address inet:host
      +--rw type unicast-configuration-type
      +--...
    +--ro associations* [address local-mode isconfigured]
      +--...
    +--ro ntp-statistics
      +--...
    +--rw interfaces
      +--rw interface* [name]
        +--rw name if:interface-ref
        +--rw broadcast-server!
          +--...
        +--rw broadcast-client!
        +--rw multicast-server* [address]
          +--rw address
          +-- rt-types:ip-multicast-group-address
          +--...
        +--rw multicast-client* [address]
          +--rw address rt-types:ip-multicast-group-address
          +--...
        +--rw manycast-server* [address]
          +--rw address rt-types:ip-multicast-group-address
          +--...
        +--rw manycast-client* [address]
          +--rw address rt-types:ip-multicast-group-address
          +--...
    +--ro ntp-statistics
      +--...
The full data model tree for the YANG module "ietf-ntp" is represented as:

module: ietf-ntp
  +--rw ntp!
    +--rw port? inet:port-number {ntp-port}?
    +--rw refclock-master!
      |  +--rw master-stratum? ntp-stratum
    +--rw authentication
      +--rw auth-enabled? boolean
      +--rw authentication-keys* [key-id]
        |   +--rw key-id uint32
        |   +--rw algorithm? identityref
        |   +--rw key? ianach:crypto-hash
        |   +--rw istrusted? boolean
      +--rw access-rules
        |   +--rw access-rule* [access-mode]
        |     +--rw access-mode access-mode
        |     +--rw acl? -> /acl:acls/acl/name
        +--ro clock-state
          | +--ro system-status
          |   +--ro clock-state ntp-clock-status
          |   +--ro clock-stratum ntp-stratum
          |   +--ro clock-refid union
          +--ro associations-address?
            | -> /ntp/associations/address
          +--ro associations-local-mode?
            | -> /ntp/associations/local-mode
          +--ro associations-isconfigured?
            | -> /ntp/associations/isconfigured
          +--ro nominal-freq decimal64
          +--ro actual-freq decimal64
          +--ro clock-precision uint8
          +--ro clock-offset? decimal64
          +--ro root-delay? decimal64
          +--ro root-dispersion? decimal64
          +--ro reference-time? yang:date-and-time
          +--ro sync-state ntp-sync-state
      +--rw unicast-configuration* [address type]
        | +--rw address inet:host
        +--rw type unicast-configuration-type
        +--rw authentication
          | +--rw (authentication-type)?
          |   | +--:(symmetric-key)
          |   |   +--rw key-id? leafref
          | +--rw prefer? boolean
          | +--rw burst? boolean
          | +--rw iburst? boolean
++-rw source?           if:interface-ref
  +--rw minpoll?          ntp-minpoll
  +--rw maxpoll?          ntp-maxpoll
  +--rw port?             inet:port-number {ntp-port}?
  +--rw version?          ntp-version
++-ro associations* [address local-mode isconfigured]
  +--ro address           inet:host
  +--ro local-mode        association-mode
  +--ro isconfigured      boolean
  +--ro stratum?          ntp-stratum
  +--ro refid?            union
  |      -> /ntp/authentication/authentication-keys/key-id
  +--ro prefer?           boolean
  +--ro peer-interface?   if:interface-ref
  +--ro minpoll?          ntp-minpoll
  +--ro maxpoll?          ntp-maxpoll
  +--ro port?             inet:port-number {ntp-port}?
  +--ro version?          ntp-version
  +--ro reach?            uint8
  +--ro unreach?          uint8
  +--ro poll?             uint8
  +--ro now?              uint32
  +--ro offset?           decimal64
  +--ro delay?            decimal64
  +--ro dispersion?       decimal64
  +--ro originate-time?   yang:date-and-time
  +--ro receive-time?     yang:date-and-time
  +--ro transmit-time?    yang:date-and-time
  +--ro input-time?       yang:date-and-time
  +--ro ntp-statistics
   |      +-ro packet-sent?        yang:counter32
   |      +-ro packet-sent-fail?   yang:counter32
   |      +-ro packet-received?    yang:counter32
   |      +-ro packet-dropped?     yang:counter32
++-rw interfaces
++-rw interface* [name]
  |      +--rw broadcast-server!
  |          +--rw name                if:interface-ref
  |          +--rw broadcast-server!   if:interface-ref
  |              |      +--rw ttl?              uint8
  |              |      +--rw authentication
  |              |          |      +--rw (authentication-type)?
  |              |          |          |      +--:(symmetric-key)
  |              |          |          |          |      +--rw key-id?   leafref
  |              |          +--rw minpoll?          ntp-minpoll
  |              |          +--rw maxpoll?          ntp-maxpoll
  |              |          +--rw port?             inet:port-number {ntp-port}?
  |              |          +--rw version?          ntp-version
This data model defines one top-level container which includes both the NTP configuration and the NTP running state including access rules, authentication, associations, unicast configurations, interfaces, system status and associations.
3. Relationship with NTPv4-MIB

If the device implements the NTPv4-MIB [RFC5907], data nodes from YANG module can be mapped to table entries in NTPv4-MIB.

The following tables list the YANG data nodes with corresponding objects in the NTPv4-MIB.

### YANG NTP Configuration Data Nodes and Related NTPv4-MIB Objects

<table>
<thead>
<tr>
<th>YANG data nodes in /ntp/clock-state/system-status</th>
<th>NTPv4-MIB objects</th>
</tr>
</thead>
<tbody>
<tr>
<td>clock-state</td>
<td>ntpEntStatusCurrentMode</td>
</tr>
<tr>
<td>clock-stratum</td>
<td>ntpEntStatusCurrentMode</td>
</tr>
<tr>
<td>clock-refid</td>
<td>ntpEntStatusActiveRefSourceId</td>
</tr>
<tr>
<td>clock-precision</td>
<td>ntpEntStatusActiveRefSourceName</td>
</tr>
<tr>
<td>clock-offset</td>
<td>ntpEntStatusActiveOffset</td>
</tr>
<tr>
<td>root-dispersion</td>
<td>ntpEntStatusDispersion</td>
</tr>
</tbody>
</table>

### YANG data nodes in /ntp/associations/ | NTPv4-MIB objects

<table>
<thead>
<tr>
<th>address</th>
<th>ntpAssocAddressType</th>
</tr>
</thead>
<tbody>
<tr>
<td>stratum</td>
<td>ntpAssocAddress</td>
</tr>
<tr>
<td>refid</td>
<td>ntpAssocStratum</td>
</tr>
<tr>
<td>offset</td>
<td>ntpAssocRefId</td>
</tr>
<tr>
<td>delay</td>
<td>ntpAssocOffset</td>
</tr>
<tr>
<td>dispersion</td>
<td>ntpAssocStatusDelay</td>
</tr>
<tr>
<td>ntp-statistics/packet-sent</td>
<td>ntpAssocStatusDispersion</td>
</tr>
<tr>
<td>ntp-statistics/packet-received</td>
<td>ntpAssocStatOutPkts</td>
</tr>
<tr>
<td>ntp-statistics/packet-dropped</td>
<td>ntpAssocStatInPkts</td>
</tr>
</tbody>
</table>

### YANG NTP State Data Nodes and Related NTPv4-MIB Objects

4. Relationship with RFC 7317

This section describes the relationship with NTP definition in Section 3.2 System Time Management of [RFC7317]. YANG data nodes in /ntp/ also supports per-interface configurations which is not supported in /system/ntp. If the yang model defined in this document is implemented, then /system/ntp SHOULD NOT be used and MUST be ignored.
5. Access Rules

As per [RFC1305] and [RFC5905], NTP could include an access-control feature that prevents unauthorized access and controls which peers are allowed to update the local clock. Further it is useful to differentiate between the various kinds of access (such as peer or server; refer access-mode) and attach different acl-rule to each. For this, the YANG module allow such configuration via /ntp/access-rules. The access-rule itself is configured via [RFC8519].

6. Key Management

As per [RFC1305] and [RFC5905], when authentication is enabled, NTP employs a crypto-checksum, computed by the sender and checked by the receiver, together with a set of predistributed algorithms, and cryptographic keys indexed by a key identifier included in the NTP message. This key-id is 32-bits unsigned integer that MUST be configured on the NTP peers before the authentication could be used. For this reason, this YANG modules allow such configuration via /ntp/authentication/authentication-keys/. Further at the time of configuration of NTP association (for example unicast-server), the key-id is specified.

7. NTP YANG Module

<CODE BEGINS> file "ietf-ntp@2019-06-26.yang"
module ietf-ntp {
    yang-version 1.1;
    namespace "urn:ietf:params:xml:ns:yang:ietf-ntp";
prefix "ntp";

import ietf-yang-types {
    prefix "yang";
    reference "RFC 6991: Common YANG Data Types";
}

import ietf-inet-types {
    prefix "inet";
    reference "RFC 6991: Common YANG Data Types";
}

import ietf-interfaces {
    prefix "if";
    reference "RFC 8343: A YANG Data Model for Interface Management";
}

import iana-crypt-hash {
    prefix "ianach";
    reference "RFC 7317: A YANG Data Model for System Management";
}

import ietf-key-chain {
    prefix "key-chain";
    reference "RFC 8177: YANG Data Model for Key Chains";
}

import ietf-access-control-list {
    prefix "acl";
    reference "RFC 8519: YANG Data Model for Network Access Control Lists (ACLs)";
}

import ietf-routing-types {
    prefix "rt-types";
    reference "RFC 8294: Common YANG Data Types for the Routing Area";
}

organization
    "IETF NTP (Network Time Protocol) Working Group";

contact
    "WG Web: <http://tools.ietf.org/wg/ntp/>
    WG List: <mailto: ntpwg@lists.ntp.org
    Editor: Eric Wu
        <mailto:eric.wu@huawei.com>
    Editor: Anil Kumar S N"
This document defines a YANG data model for Network Time Protocol (NTP) implementations. The data model includes configuration data and state data.

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

revision 2019-06-26 {
  description
    "Initial revision.";
  reference
    "RFC XXXX: A YANG Data Model for NTP.";
}

/* Note: The RFC Editor will replace XXXX with the number assigned to this document once it becomes an RFC.*/

/* Typedef Definitions */

typedef ntp-stratum {
  type uint8 {
    range "1..16";
  }
  description
    "The level of each server in the hierarchy is defined by a stratum. Primary servers are assigned with stratum one; secondary servers at each lower level are assigned with one stratum greater than the preceding level";
  reference
    "RFC 5905: Network Time Protocol Version 4: Protocol and
typedef ntp-version {
    type uint8;
    default "3";
    description "The current NTP version supported by corresponding association.";
}

typedef ntp-minpoll {
    type uint8 {
        range "4..17";
    }
    default "6";
    description "The minimum poll exponent for this NTP association.";
}

typedef ntp-maxpoll {
    type uint8 {
        range "4..17";
    }
    default "10";
    description "The maximum poll exponent for this NTP association.";
}

typedef access-mode {
    type enumeration {
        enum peer {
            value "0";
            description "Enables the full access authority. Both time request and control query can be performed on the local NTP service, and the local clock can be synchronized with the remote server.";
        }
        enum server {
            value "1";
            description
            "The server mode enables the server to act as a client. The server
            can request time information from a remote server that might be
            running a different version of NTP. The server mode is primarily
            used to synchronize a network with a remote server."
        }
    }
}

"Enables the server access and query. Both time requests and control query can be performed on the local NTP service, but the local clock cannot be synchronized with the remote server."

enum synchronization {
  value "2";
  description
    "Enables the server to access. Only time request can be performed on the local NTP service.";
}

enum query {
  value "3";
  description
    "Enables the maximum access limitation. Control query can be performed only on the local NTP service.";
}

description
  "This defines NTP access modes."
}

typedef unicast-configuration-type {
  type enumeration {
    enum server {
      value "0";
      description
        "Use client association mode. This device will not provide synchronization to the configured NTP server.";
    }
    enum peer {
      value "1";
      description
        "Use symmetric active association mode. This device may provide synchronization to the configured NTP server.";
    }
  }
  description
    "This defines NTP unicast mode of operation."
}

typedef association-mode {
  type enumeration {
    enum client {

value "0";
description
  "Use client association mode(mode 3).
  This device will not provide synchronization
  to the configured NTP server."
}
enum active {
  value "1";
description
  "Use symmetric active association mode(mode 1).
  This device may synchronize with its NTP peer,
  or provide synchronization to configured NTP peer.";
}
enum passive {
  value "2";
description
  "Use symmetric passive association mode(mode 2).
  This device has learned this association dynamically.
  This device may synchronize with its NTP peer.";
}
enum broadcast {
  value "3";
description
  "Use broadcast mode(mode 5).
  This mode defines that its either working
  as broadcast-server or multicast-server.";
}
enum broadcast-client {
  value "4";
description
  "This mode defines that its either working
  as broadcast-client or multicast-client.";
}
}
description
  "The NTP association modes."
}
typedef ntp-clock-status {
type enumeration {
  enum synchronized {
    value "0";
description
      "Indicates that the local clock has been
      synchronized with an NTP server or
      the reference clock.";
  }
  enum unsynchronized {

typedef ntp-sync-state {
  type enumeration {
    enum clock-not-set {
      value "0";
      description "Indicates the clock is not updated.";
    }
    enum freq-set-by-cfg {
      value "1";
      description "Indicates the clock frequency is set by NTP configuration.";
    }
    enum clock-set {
      value "2";
      description "Indicates the clock is set.";
    }
    enum freq-not-determined {
      value "3";
      description "Indicates the clock is set but the frequency is not determined.";
    }
    enum clock-synchronized {
      value "4";
      description "Indicates that the clock is synchronized";
    }
    enum spike {
      value "5";
      description "Indicates a time difference of more than 128 milliseconds is detected between NTP server and client clock. The clock change will take effect in XXX seconds.";
    }
  }
}
description
  "This defines NTP clock sync states."
}

/**< features */
feature ntp-port {
    description
        "Support for NTP port configuration";
    reference
        "RFC 5905: Network Time Protocol Version 4: Protocol and
        Algorithms Specification"
}

feature authentication {
    description
        "Support for NTP symmetric key authentication";
    reference
        "RFC 5905: Network Time Protocol Version 4: Protocol and
        Algorithms Specification"
}

feature access-rules {
    description
        "Support for NTP access control";
    reference
        "RFC 5905: Network Time Protocol Version 4: Protocol and
        Algorithms Specification"
}

feature unicast-configuration {
    description
        "Support for NTP client/server or active/passive
        in unicast";
    reference
        "RFC 5905: Network Time Protocol Version 4: Protocol and
        Algorithms Specification"
}

feature broadcast-server {
    description
        "Support for broadcast server";
    reference
        "RFC 5905: Network Time Protocol Version 4: Protocol and
        Algorithms Specification"
}

feature broadcast-client {
    description
"Support for broadcast client";
reference
}

feature multicast-server {
    description
    "Support for multicast server";
    reference
}

feature multicast-client {
    description
    "Support for multicast client";
    reference
}

feature manycast-server {
    description
    "Support for manycast server";
    reference
}

feature manycast-client {
    description
    "Support for manycast client";
    reference
}

/* Groupings */
grouping authentication-key {
    description
    "To define an authentication key for a Network Time Protocol (NTP) time source."
    leaf key-id {
        type uint32 {
            range "1..max";
        }
    }
}
description
  "Authentication key identifier."
};
leaf algorithm {
  type identityref {
    base key-chain:crypto-algorithm;
  }
  description
    "Authentication algorithm."
};
leaf key {
  type ianach:crypt-hash;
  description
    "The key";
}
leaf istrusted {
  type boolean;
  description
    "Key-id is trusted or not";
}
reference
}
grouping authentication {
  description
    "Authentication."
  choice authentication-type {
    description
      "Type of authentication.";
    case symmetric-key {
      leaf key-id {
        type leafref {
          path "/ntp:ntp/ntp:authentication/
            + "ntp:authentication-keys/ntp:key-id";
        }
        description
          "Authentication key id referenced in this association.";
      }
    }
  }
}
grouping statistics {
  description
    "NTP packet statistic.";
leaf packet-sent {
    type yang:counter32;
    description
    "The total number of NTP packets delivered to the transport service by this NTP entity for this association. Discontinuities in the value of this counter can occur upon cold start or reinitialization of the NTP entity, the management system and at other times as indicated by discontinuities in the value of sysUpTime.";
}

leaf packet-sent-fail {
    type yang:counter32;
    description
    "The number of times NTP packets sending failed.";
}

leaf packet-received {
    type yang:counter32;
    description
    "The total number of NTP packets delivered to the NTP entity from this association. Discontinuities in the value of this counter can occur upon cold start or reinitialization of the NTP entity, the management system and at other times as indicated by discontinuities in the value of sysUpTime.";
}

leaf packet-dropped {
    type yang:counter32;
    description
    "The total number of NTP packets that were delivered to this NTP entity from this association and this entity was not able to process due to an NTP protocol error. Discontinuities in the value of this counter can occur upon cold start or reinitialization of the NTP entity, the management system and at other times as indicated by discontinuities in the value of sysUpTime.";
}

grouping common-attributes {
    description
    "NTP common attributes for configuration.";
    leaf minpoll {
        type ntp-minpoll;
        description
        "The minimum poll interval used in this association.";
    }
    leaf maxpoll {
type ntp-maxpoll;
description
"The maximum poll interval used in this association.";
}
leaf port {
  if-feature ntp-port;
  type inet:port-number {
    range "123 | 1025..max";
  }
  default "123";
  description
  "Specify the port used to send NTP packets.";
}
leaf version {
  type ntp-version;
  description
  "NTP version.";
}
reference
"RFC 5905: Network Time Protocol Version 4: Protocol and
Algorithms Specification";

}

grouping association-ref {
  description
  "Reference to NTP association mode";
  leaf associations-address {
    type leafref {
      path "/ntp:ntp/ntp:associations/ntp:address";
    }
    description
    "Indicates the association’s address
     which result in clock synchronization.";
  }
  leaf associations-local-mode {
    type leafref {
      path "/ntp:ntp/ntp:associations/ntp:local-mode";
    }
    description
    "Indicates the association’s local-mode
     which result in clock synchronization.";
  }
  leaf associations-isconfigured {
    type leafref {
      path "/ntp:ntp/ntp:associations/
      + "ntp:isconfigured";
    }
  }
}
description
"The association was configured or dynamic
which result in clock synchronization."
}
}

/* Configuration data nodes */
container ntp {
presence
"NTP is enabled and system should attempt to
synchronize the system clock with an NTP server
from the 'ntp/associations' list.";
description
"Configuration parameters for NTP.";
leaf port {
if-feature ntp-port;
type inet:port-number {
   range "123 | 1025..max";
}
default "123";
description
"Specify the port used to send and receive NTP packets.";
}
container refclock-master {
presence
"NTP master clock is enabled.";
description
"Configures the local clock of this device as NTP server.";
leaf master-stratum {
type ntp-stratum;
default "16";
description
"Stratum level from which NTP
clients get their time synchronized."
}
}
container authentication {
description
"Configuration of authentication.";
leaf auth-enabled {
type boolean;
default false;
description
"Controls whether NTP authentication is enabled
or disabled on this device.";
}
list authentication-keys {
   key "key-id";
uses authentication-key;
    description
        "List of authentication keys.";
  }
}

container access-rules {
    description
        "Configuration to control access to NTP service by using NTP access-group feature. The access-mode identifies how the acl is applied with NTP.";
    list access-rule {
        key "access-mode";
        description
            "List of access rules.";
        leaf access-mode {
            type access-mode;
            description
                "NTP access mode. The definition of each possible values:
                peer(0): Both time request and control query can be performed.
                server(1): Enables the server access and query.
                synchronization(2): Enables the server access only.
                query(3): Enables control query only.";
        }
        leaf acl {
            type leafref {
                path "/acl:acls/acl:acl/acl:name";
            }
            description
                "Control access configuration to be used.";
        }
        reference
    }
}

container clock-state {
    config "false";
    description
        "Clock operational state of the NTP.";
}

container system-status {
    description
        "System status of NTP.";
    leaf clock-state {

type ntp-clock-status;
mandatory true;
description
"The state of system clock. The definition of each
possible value is:
synchronized(0): Indicates local clock is synchronized.
unsynchronized(1): Indicates local clock is not
synchronized."
}
leaf clock-stratum {
    type ntp-stratum;
    mandatory true;
description
    "The NTP entity’s own stratum value. Should be a stratum
    of syspeer + 1 (or 16 if no syspeer)."
reference
    "RFC 5905: Network Time Protocol Version 4: Protocol and
    Algorithms Specification"
}
leaf clock-refid {
    type union {
        type inet:ipv4-address;
        type binary {
            length "4";
        }
        type string {
            length "4";
        }
    }
    mandatory true;
description
    "IPv4 address or first 32 bits of the MD5 hash of
    the IPv6 address or reference clock of the peer to
    which clock is synchronized."
reference
    "RFC 5905: Network Time Protocol Version 4: Protocol and
    Algorithms Specification"
}

uses association-ref {
    description
    "Reference to Association."
}

leaf nominal-freq {
    type decimal64 {
        fraction-digits 4;
    }
}
units Hz;
mandatory true;
description
  "The nominal frequency of the
  local clock.";
reference
  "RFC 5905: Network Time Protocol Version 4: Protocol and
  Algorithms Specification";
}
leaf actual-freq {
  type decimal64 {
    fraction-digits 4;
  }
  units Hz;
  mandatory true;
description
  "The actual frequency of the
  local clock.";
reference
  "RFC 5905: Network Time Protocol Version 4: Protocol and
  Algorithms Specification";
}
leaf clock-precision {
  type uint8;
  units Hz;
  mandatory true;
description
  "Clock precision of this system in integer format
  (prec=2^(-n)). A value of 5 would mean 2^-5 = 31.25 ms.";
reference
  "RFC 5905: Network Time Protocol Version 4: Protocol and
  Algorithms Specification";
}
leaf clock-offset {
  type decimal64 {
    fraction-digits 3;
  }
  units milliseconds;
description
  "The time offset to the current selected reference time
  source e.g., '0.032' or '1.232'.";
reference
  "RFC 5905: Network Time Protocol Version 4: Protocol and
  Algorithms Specification";
}
leaf root-delay {
  type decimal64 {
    fraction-digits 3;
  }

leaf root-dispersion {
  type decimal64 {
    fraction-digits 3;
  }
  units milliseconds;
  description
    "The dispersion between the local clock and the root clock, e.g., ‘6.927’.";
  reference
}

leaf reference-time {
  type yang:date-and-time;
  description
    "The reference timestamp.";
}

leaf sync-state {
  type ntp-sync-state;
  mandatory true;
  description
    "The synchronization status of the local clock.";
}

list unicast-configuration {
  key "address type";
  description
    "List of NTP unicast-configurations.";
  leaf address {
    type inet:host;
    description
      "Address of this association.";
  }
  leaf type {
    type unicast-configuration-type;
    description
      "Use client association mode. This device will not provide synchronization to the
configured NTP server.
}
}

container authentication{
    description "Authentication used for this association.";
    uses authentication;
}

leaf prefer {
    type boolean;
    default "false";
    description "Whether this association is preferred or not.";
}

leaf burst {
    type boolean;
    default "false";
    description "If set, a series of packets are sent instead of a single packet within each synchronization interval to achieve faster synchronization.";
}

leaf iburst {
    type boolean;
    default "false";
    description "If set, a series of packets are sent instead of a single packet within the initial synchronization interval to achieve faster initial synchronization.";
}

leaf source {
    type if:interface-ref;
    description "The interface whose IP address is used by this association as the source address.";
}

uses common-attributes {
    description "Common attributes like port, version, min and max poll.";
}
}

list associations {
key "address local-mode isconfigured";
config "false";
description

"List of NTP associations. Here address, local-mode and isconfigured is required to uniquely identify a particular association. Lets take following examples -

1) If RT1 acting as broadcast server, and RT2 acting as broadcast client, then RT2 will form dynamic association with address as RT1, local-mode as client and isconfigured as false.

2) When RT2 is configured with unicast-server RT1, then RT2 will form association with address as RT1, local-mode as client and isconfigured as true.

Thus all 3 leaves are needed as key to unique identify the association."

leaf address {
  type inet:host;
description
   "The address of this association. Represents the IP address of a unicast/multicast/broadcast address."
}
leaf local-mode {
  type association-mode;
description
   "Local mode of this NTP association."
}
leaf isconfigured {
  type boolean;
description
   "Indicates if this association is configured or dynamically learned."
}
leaf stratum {
  type ntp-stratum;
description
   "The association stratum value."
reference
}
leaf refid {
  type union {
    type inet:ipv4-address;
    type binary {
length "4";
}  

leaf prefer {
  type boolean;
  default "false";
  description "Indicates if this association is preferred.";
}

leaf peer-interface {
  type if:interface-ref;
  description "The interface which is used for communication.";
}

uses common-attributes {
  description "Common attributes like port, version, min and max poll.";
}

leaf reach {
  type uint8;
  description "The reachability of the configured server or peer.";
  reference
}
}
leaf unreach {
  type uint8;
  description
    "The unreachability of the configured server or peer.";
  reference
}
leaf poll {
  type uint8;
  units seconds;
  description
    "The polling interval for current association";
  reference
}
leaf now {
  type uint32;
  units seconds;
  description
    "The time since the NTP packet was not received or last synchronized.";
  reference
}
leaf offset {
  type decimal64 {
    fraction-digits 3;
  }
  units milliseconds;
  description
    "The offset between the local clock and the peer clock, e.g., '0.032' or '1.232'";
  reference
}
leaf delay {
  type decimal64 {
    fraction-digits 3;
  }
  units milliseconds;
description
 "The network delay between the local clock
 and the peer clock."
reference
 "RFC 5905: Network Time Protocol Version 4: Protocol and
 Algorithms Specification"

leaf dispersion {
type decimal64 {
   fraction-digits 3;
}
units milliseconds;
description
 "The root dispersion between the local clock
 and the peer clock."
reference
 "RFC 5905: Network Time Protocol Version 4: Protocol and
 Algorithms Specification"

leaf originate-time {
type yang:date-and-time;
description
 "This is the local time, in timestamp format,
 when latest NTP packet was sent to peer(T1)."
reference
 "RFC 5905: Network Time Protocol Version 4: Protocol and
 Algorithms Specification"

leaf receive-time {
type yang:date-and-time;
description
 "This is the local time, in timestamp format,
 when latest NTP packet arrived at peer(T2).
 If the peer becomes unreachable the value is set to zero."
reference
 "RFC 5905: Network Time Protocol Version 4: Protocol and
 Algorithms Specification"

leaf transmit-time {
type yang:date-and-time;
description
 "This is the local time, in timestamp format,
 at which the NTP packet departed the peer(T3).
 If the peer becomes unreachable the value is set to zero."
reference
 "RFC 5905: Network Time Protocol Version 4: Protocol and
 Algorithms Specification"
leaf input-time {
  type yang:date-and-time;
  description
    "This is the local time, in timestamp format,
     when the latest NTP message from the peer arrived(T4).
     If the peer becomes unreachable the value is set to zero.";
  reference
    "RFC 5905: Network Time Protocol Version 4: Protocol and
     Algorithms Specification";
}

container ntp-statistics {
  description
    "Per Peer packet send and receive statistics.";
  uses statistics {
    description
      "NTP send and receive packet statistics.";
  }
}

container interfaces {
  description
    "Configuration parameters for NTP interfaces.";
  list interface {
    key "name";
    description
      "List of interfaces.";
    leaf name {
      type if:interface-ref;
      description
        "The interface name.";
    }
  }
  container broadcast-server {
    presence
      "NTP broadcast-server is configured";
    description
      "Configuration of broadcast server.";
    leaf ttl {
      type uint8;
      description
        "Specifies the time to live (TTL) for a
         broadcast packet.";
    }
  }
  container authentication{
    description
      "Authentication used for this association.";
    uses authentication;
uses common-attributes {
  description
  "Common attribute like port, version, min and max poll.";
}
reference

container broadcast-client {
  presence
  "NTP broadcast-client is configured.";
  description
  "Configuration of broadcast-client.";
  reference
}

list multicast-server {
  key "address";
  description
  "Configuration of multicast server.";
  leaf address {
    type rt-types:ip-multicast-group-address;
    description
    "The IP address to send NTP multicast packets.";
  }
  leaf ttl {
    type uint8;
    description
    "Specifies the time to live (TTL) for a multicast packet.";
  }
}

container authentication{
  description
  "Authentication used for this association.";
  uses authentication;
}

uses common-attributes {
  description
  "Common attributes like port, version, min and max poll.";
}
reference
list multicast-client {
  key "address";
  description "Configuration of multicast-client.";
  leaf address {
    type rt-types:ip-multicast-group-address;
    description "The IP address of the multicast group to join.";
  }
}

list manycast-server {
  key "address";
  description "Configuration of manycast server.";
  leaf address {
    type rt-types:ip-multicast-group-address;
    description "The multicast group IP address to receive manycast client messages.";
  }
}

list manycast-client {
  key "address";
  description "Configuration of manycast-client.";
  leaf address {
    type rt-types:ip-multicast-group-address;
    description "The group IP address that the manycast client broadcasts the request message to.";
  }
  container authentication{
    description "Authentication used for this association.";
    uses authentication;
  }
  leaf ttl {
    type uint8;
    description "Specifies the maximum time to live (TTL) for the expanding ring search.";
  }
}
leaf minclock {
    type uint8;
    description
        "The minimum manycast survivors in this
        association.";
}
leaf maxclock {
    type uint8;
    description
        "The maximum manycast candidates in this
        association.";
}
leaf beacon {
    type uint8;
    description
        "The maximum interval between beacons in this
        association.";
}
uses common-attributes {
    description
        "Common attributes like port, version, min and
        max poll.";
} reference
    "RFC 5905: Network Time Protocol Version 4: Protocol and
    Algorithms Specification";
}
}
container ntp-statistics {
    config "false";
    description
        "Total NTP packet statistics.";
    uses statistics {
        description
            "NTP send and receive packet statistics.";
    }
}

8. Usage Example

This section include examples for illustration purposes.
8.1. Unicast association

This example describes how to configure a preferred unicast server present at 192.0.2.1 running at port 1025 with authentication-key 10 and version 4

```xml
<edit-config xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <target>
    <running/>
  </target>
  <config>
    <ntp xmlns="urn:ietf:params:xml:ns:yang:ietf-ntp">
      <unicast-configuration>
        <address>192.0.2.1</address>
        <type>server</type>
        <prefer>true</prefer>
        <version>4</version>
        <port>1025</port>
        <authentication>
          <symmetric-key>
            <key-id>10</key-id>
          </symmetric-key>
        </authentication>
      </unicast-configuration>
    </ntp>
  </config>
</edit-config>
```

An example with IPv6 would use the IPv6 address (say 2001:DB8::1) in the "address" leaf with no change in any other data tree.

This example is for retrieving unicast configurations -

```xml
<get>
  <filter type="subtree">
      <sys:unicast-configuration>...
    </sys:unicast-configuration>
  </sys:ntp>
</filter>
</get>
```

```xml
<data xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <ntp xmlns="urn:ietf:params:xml:ns:yang:ietf-ntp">
    <unicast-configuration>
      <address>192.0.2.1</address>
      <type>server</type>
      <authentication>...
    </unicast-configuration>
  </ntp>
</data>
```
<symmetric-key>
  <key-id>10</key-id>
</symmetric-key>
</authentication>
<prefer>true</prefer>
<burst>false</burst>
<iburst>true</iburst>
<source/>
<minpoll>6</minpoll>
<maxpoll>10</maxpoll>
<port>1025</port>
<version>4</version>
<stratum>9</stratum>
<refid>20.1.1.1</refid>
<reach>255</reach>
<unreach>0</unreach>
<poll>128</poll>
<now>10</now>
<offset>0.025</offset>
<delay>0.5</delay>
<dispersion>0.6</dispersion>
<originate-time>2017-10-10 07:33:55.253 Z+05:30</originate-time>
<receive-time>2017-10-10 07:33:55.258 Z+05:30</receive-time>
<transmit-time>2017-10-10 07:33:55.300 Z+05:30</transmit-time>
<input-time>2017-10-10 07:33:55.305 Z+05:30</input-time>
<ntp-statistics>
  <packet-sent>20</packet-sent>
  <packet-sent-fail>0</packet-sent-fail>
  <packet-received>20</packet-received>
  <packet-dropped>0</packet-dropped>
</ntp-statistics>
</unicast-configuration>
</ntp>
</data>

8.2. Refclock master

This example describes how to configure reference clock with stratum 8 -
<edit-config xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <target>
    <running/>
  </target>
  <config>
    <ntp xmlns="urn:ietf:params:xml:ns:yang:ietf-ntp">
      <refclock-master>
        <master-stratum>8</master-stratum>
      </refclock-master>
    </ntp>
  </config>
</edit-config>

This example describes how to get reference clock configuration -

<get>
  <filter type="subtree">
      <sys:refclock-master>
        <master-stratum>8</master-stratum>
      </sys:refclock-master>
    </sys:ntp>
  </filter>
</get>

<data xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <ntp xmlns="urn:ietf:params:xml:ns:yang:ietf-ntp">
    <refclock-master>
      <master-stratum>8</master-stratum>
    </refclock-master>
  </ntp>
</data>

### 8.3. Authentication configuration

This example describes how to enable authentication and configure trusted authentication key 10 with mode as md5 and key as 'abcd' -
<edit-config xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <target>
    <running/>
  </target>
  <config>
    <ntp xmlns="urn:ietf:params:xml:ns:yang:ietf-ntp">
      <authentication>
        <auth-enabled>true</auth-enabled>
        <authentication-keys>
          <key-id>10</key-id>
          <algorithm>md5</algorithm>
          <key>abcd</key>
          <istrusted>true</istrusted>
        </authentication-keys>
      </authentication>
    </ntp>
  </config>
</edit-config>

This example describes how to get authentication related configuration -

<get>
  <filter type="subtree">
      <sys:authentication>
        <authentication-keys>
          <key-id>10</key-id>
          <algorithm>md5</algorithm>
          <key>abcd</key>
          <istrusted>true</istrusted>
        </authentication-keys>
      </sys:authentication>
    </sys:ntp>
  </filter>
</get>

<data xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <ntp xmlns="urn:ietf:params:xml:ns:yang:ietf-ntp">
    <authentication>
      <auth-enabled>false</auth-enabled>
      <trusted-keys/>
      <authentication-keys>
        <key-id>10</key-id>
        <algorithm>md5</algorithm>
        <key>abcd</key>
        <istrusted>true</istrusted>
      </authentication-keys>
    </authentication>
  </ntp>
</data>
8.4. Access configuration

This example describes how to configure access mode "peer" associated with acl 2000 -

```xml
<edit-config xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <target>
    <running/>
  </target>
  <config>
    <ntp xmlns="urn:ietf:params:xml:ns:yang:ietf-ntp">
      <access-rules>
        <access-rule>
          <access-mode>peer</access-mode>
          <acl>2000</acl>
        </access-rule>
      </access-rules>
    </ntp>
  </config>
</edit-config>
```

This example describes how to get access related configuration -

```xml
<get>
  <filter type="subtree">
      <sys:access-rules>
      </sys:access-rules>
    </sys:ntp>
  </filter>
</get>
```

```xml
<data xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <ntp xmlns="urn:ietf:params:xml:ns:yang:ietf-ntp">
    <access-rules>
      <access-rule>
        <access-mode>peer</access-mode>
        <acl>2000</acl>
      </access-rule>
    </access-rules>
  </ntp>
</data>
```

8.5. Multicast configuration

This example describes how to configure multicast-server with address as "224.1.1.1", port as 1025 and authentication keyid as 10 -
This example describes how to get multicast-server related configuration -
<get>
  <filter type="subtree">
      <sys:interfaces>
        <sys:interface>
          <sys:multicast-server/>
        </sys:interface>
      </sys:interfaces>
    </sys:ntp>
  </filter>
</get>

<data xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <ntp xmlns="urn:ietf:params:xml:ns:yang:ietf-ntp">
    <interfaces>
      <interface>
        <name>Ethernet3/0/0</name>
        <multicast-server>
          <address>224.1.1.1</address>
          <ttl>224.1.1.1</ttl>
          <authentication>
            <symmetric-key>
              <key-id>10</key-id>
            </symmetric-key>
          </authentication>
          <minpoll>6</minpoll>
          <maxpoll>10</maxpoll>
          <port>1025</port>
          <version>3</version>
        </multicast-server>
      </interface>
    </interfaces>
  </ntp>
</data>

This example describes how to configure multicast-client with address as "224.1.1.1" -
<edit-config xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <target>
    <running/>
  </target>
  <config>
    <ntp xmlns="urn:ietf:params:xml:ns:yang:ietf-ntp">
      <interfaces>
        <interface>
          <name>Ethernet3/0/0</name>
          <multicast-client>
            <address>224.1.1.1</address>
          </multicast-client>
        </interface>
      </interfaces>
    </ntp>
  </config>
</edit-config>

This example describes how to get multicast-client related configuration -

<get>
  <filter type="subtree">
      <sys:interfaces>
        <sys:interface>
          <sys:multicast-client>
            </sys:multicast-client>
        </sys:interface>
      </sys:interfaces>
    </sys:ntp>
  </filter>
</get>

<data xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <ntp xmlns="urn:ietf:params:xml:ns:yang:ietf-ntp">
    <interfaces>
      <interface>
        <name>Ethernet3/0/0</name>
        <multicast-client>
          <address>224.1.1.1</address>
        </multicast-client>
      </interface>
    </interfaces>
  </ntp>
</data>
8.6. Manycast configuration

This example describes how to configure manycast-client with address as "224.1.1.1", port as 1025 and authentication keyid as 10 -

<edit-config xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <target>
    <running/>
  </target>
  <config>
    <ntp xmlns="urn:ietf:params:xml:ns:yang:ietf-ntp">
      <interfaces>
        <interface>
          <name>Ethernet3/0/0</name>
          <manycast-client>
            <address>224.1.1.1</address>
            <authentication>
              <symmetric-key>
                <key-id>10</key-id>
              </symmetric-key>
            </authentication>
            <port>1025</port>
          </manycast-client>
        </interface>
      </interfaces>
    </ntp>
  </config>
</edit-config>

This example describes how to get manycast-client related configuration -
<filter type="subtree">
    <sys:interfaces>
      <sys:interface>
        <sys:manycast-client>
        </sys:manycast-client>
      </sys:interface>
    </sys:interfaces>
  </sys:ntp>
</filter>
</get>

This example describes how to configure manycast-server with address as "224.1.1.1" -
<edit-config xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <target>
    <running/>
  </target>
  <config>
    <ntp xmlns="urn:ietf:params:xml:ns:yang:ietf-ntp">
      <interfaces>
        <interface>
          <name>Ethernet3/0/0</name>
          <manycast-server>
            <address>224.1.1.1</address>
          </manycast-server>
        </interface>
      </interfaces>
    </ntp>
  </config>
</edit-config>

This example describes how to get manycast-server related configuration -

<get>
  <filter type="subtree">
      <sys:interfaces>
        <sys:interface>
          <sys:manycast-server/>
        </sys:interface>
      </sys:interfaces>
    </sys:ntp>
  </filter>
</get>

<data xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <ntp xmlns="urn:ietf:params:xml:ns:yang:ietf-ntp">
    <interfaces>
      <interface>
        <name>Ethernet3/0/0</name>
        <manycast-server>
          <address>224.1.1.1</address>
        </manycast-server>
      </interface>
    </interfaces>
  </ntp>
</data>
8.7. Clock state

This example describes how to get clock current state -

```xml
<get>
  <filter type="subtree">
      <sys:clock-state>
        <system-status>
          <clock-state>synchronized</clock-state>
          <clock-stratum>7</clock-stratum>
          <clock-refid>192.0.2.1</clock-refid>
          <associations-address>192.0.2.1</associations-address>
          <associations-local-mode>client</associations-local-mode>
          <associations-isconfigured>yes</associations-isconfigured>
          <nominal-freq>100.0</nominal-freq>
          <actual-freq>100.0</actual-freq>
          <clock-precision>18</clock-precision>
          <clock-offset>0.025</clock-offset>
          <root-delay>0.5</root-delay>
          <root-dispersion>0.8</root-dispersion>
          <reference-time>10-10-2017 07:33:55.258 Z+05:30</reference-time>
        </system-status>
      </sys:clock-state>
    </sys:ntp>
  </filter>
</get>
```

8.8. Get all association

This example describes how to get all association present in the system -
<get>
  <filter type="subtree">
      <sys:associations/>
    </sys:ntp>
  </filter>
</get>

<data xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <ntp xmlns="urn:ietf:params:xml:ns:yang:ietf-ntp">
    <associations>
      <address>192.0.2.1</address>
      <stratum>9</stratum>
      <refid>20.1.1.1</refid>
      <local-mode>client</local-mode>
      <isconfigured>true</isconfigured>
      <authentication-key>10</authentication-key>
      <prefer>true</prefer>
      <peer-interface>Ethernet3/0/0</peer-interface>
      <minpoll>6</minpoll>
      <maxpoll>10</maxpoll>
      <minport>1025</minport>
      <maxport>1025</maxport>
      <version>4</version>
      <reach>255</reach>
      <unreach>0</unreach>
      <poll>128</poll>
      <now>10</now>
      <offset>0.025</offset>
      <delay>0.5</delay>
      <dispersion>0.6</dispersion>
      <originate-time>10-10-2017 07:33:55.253 Z+05:30</originate-time>
      <receive-time>10-10-2017 07:33:55.258 Z+05:30</receive-time>
      <transmit-time>10-10-2017 07:33:55.300 Z+05:30</transmit-time>
      <input-time>10-10-2017 07:33:55.305 Z+05:30</input-time>
    </associations>
    <ntp-statistics>
      <packet-sent>20</packet-sent>
      <packet-sent-fail>0</packet-sent-fail>
      <packet-received>20</packet-received>
      <packet-dropped>0</packet-dropped>
    </ntp-statistics>
  </ntp>
</data>
8.9. Global statistic

This example describes how to get clock current state -

```
<get>
  <filter type="subtree">
      <sys:ntp-statistics>
        </sys:ntp-statistics>
    </sys:ntp>
  </filter>
</get>
```

```
<data xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <ntp xmlns="urn:ietf:params:xml:ns:yang:ietf-ntp">
    <ntp-statistics>
      <packet-sent>30</packet-sent>
      <packet-sent-fail>5</packet-sent-fail>
      <packet-received>20</packet-received>
      <packet-dropped>2</packet-dropped>
    </ntp-statistics>
  </ntp>
</data>
```

9. IANA Considerations

This document registers a URI in the "IETF XML Registry" [RFC3688]. Following the format in RFC 3688, the following registration has been made.


Registrant Contact: The IESG.

XML: N/A; the requested URI is an XML namespace.

This document registers a YANG module in the "YANG Module Names" registry [RFC6020].

Name: ietf-ntp


Prefix: ntp

Reference: RFC XXXX
10. Security Considerations

The YANG module specified in this document defines a schema for data that is designed to be accessed via network management protocols such as NETCONF [RFC6241] or RESTCONF [RFC8040]. The lowest NETCONF layer is the secure transport layer, and the mandatory-to-implement secure transport is Secure Shell (SSH) [RFC6242]. The lowest RESTCONF layer is HTTPS, and the mandatory-to-implement secure transport is TLS [RFC8446].

The NETCONF access control model [RFC8341] provides the means to restrict access for particular NETCONF or RESTCONF users to a preconfigured subset of all available NETCONF or RESTCONF protocol operations and content.

There are a number of data nodes defined in this YANG module that are writable/creatable/deletable (i.e., config true, which is the default). These data nodes may be considered sensitive or vulnerable in some network environments. Write operations (e.g., edit-config) to these data nodes without proper protection can have a negative effect on network operations. These are the subtrees and data nodes and their sensitivity/vulnerability:

/ntp/port - This data node specify the port number to be used to send NTP packets. Unexpected changes could lead to disruption and/or network misbehavior.

/ntp/authentication and /ntp/access-rules - The entries in the list include the authentication and access control configurations. Care should be taken while setting these parameters.

/ntp/unicast-configuration - The entries in the list include all unicast configurations (server or peer mode), and indirectly creates or modify the NTP associations. Unexpected changes could lead to disruption and/or network misbehavior.

/ntp/interfaces/interface - The entries in the list include all per-interface configurations related to broadcast, multicast and manycast mode, and indirectly creates or modify the NTP associations. Unexpected changes could lead to disruption and/or network misbehavior.

Some of the readable data nodes in this YANG module may be considered sensitive or vulnerable in some network environments. It is thus important to control read access (e.g., via get, get-config, or...
notification) to these data nodes. These are the subtrees and data
nodes and their sensitivity/vulnerability:

/ntp/associations – The entries in the list includes all active
NTP associations of all modes. Unauthorized access to this needs
to be curtailed.

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12. References

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