

NETCONF Client and Server Models
draft-ietf-netconf-netconf-client-server-12

Abstract

This document defines two YANG modules, one module to configure a NETCONF client and the other module to configure a NETCONF server. Both modules support both the SSH and TLS transport protocols, and support both standard NETCONF and NETCONF Call Home connections.

Editorial Note (To be removed by RFC Editor)

This draft contains many placeholder values that need to be replaced with finalized values at the time of publication. This note summarizes all of the substitutions that are needed. No other RFC Editor instructions are specified elsewhere in this document.

This document contains references to other drafts in progress, both in the Normative References section, as well as in body text throughout. Please update the following references to reflect their final RFC assignments:

- o I-D.ietf-netconf-keystore
- o I-D.ietf-netconf-tcp-client-server
- o I-D.ietf-netconf-ssh-client-server
- o I-D.ietf-netconf-tls-client-server

Artwork in this document contains shorthand references to drafts in progress. Please apply the following replacements:

- o "XXXX" --> the assigned RFC value for this draft
- o "AAAA" --> the assigned RFC value for I-D.ietf-netconf-tcp-client-server
- o "YYYY" --> the assigned RFC value for I-D.ietf-netconf-ssh-client-server

- o "ZZZZ" --> the assigned RFC value for I-D.ietf-netconf-tls-client-server

Artwork in this document contains placeholder values for the date of publication of this draft. Please apply the following replacement:

- o "2019-04-29" --> the publication date of this draft

The following Appendix section is to be removed prior to publication:

- o [Appendix B](#). Change Log

Status of This Memo

This Internet-Draft is submitted in full conformance with the provisions of [BCP 78](#) and [BCP 79](#).

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[1.](#) Introduction

This document defines two YANG [[RFC7950](#)] modules, one module to configure a NETCONF [[RFC6241](#)] client and the other module to configure a NETCONF server. Both modules support both NETCONF over SSH [[RFC6242](#)] and NETCONF over TLS [[RFC7589](#)] and NETCONF Call Home connections [[RFC8071](#)].

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2. Terminology

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.

3. The NETCONF Client Model

The NETCONF client model presented in this section supports both clients initiating connections to servers, as well as clients listening for connections from servers calling home, using either the SSH and TLS transport protocols.

YANG feature statements are used to enable implementations to advertise which potentially uncommon parts of the model the NETCONF client supports.

3.1. Tree Diagram

The following tree diagram [[RFC8340](#)] provides an overview of the data model for the "ietf-netconf-client" module.

This tree diagram only shows the nodes defined in this module; it does show the nodes defined by "grouping" statements used by this module.

Please see [Appendix A.1](#) for a tree diagram that illustrates what the module looks like with all the "grouping" statements expanded.

```

module: ietf-netconf-client
  +--rw netconf-client
    +---u netconf-client-grouping

    grouping netconf-client-grouping
      +-- initiate! {ssh-initiate or tls-initiate}?
        | +-- netconf-server* [name]
        |   +-- name? string
        |   +-- endpoints
        |     | +-- endpoint* [name]
        |     |   +-- name? string
        |     |   +-- (transport)
        |     |     +--:(ssh) {ssh-initiate}?
        |     |       | +-- ssh
        |     |       |   +-- tcp-client-parameters
        |     |       |   | +---u netconf-client-grouping
        |     |       |   +-- ssh-client-parameters

```



```

|         |         |         +---u netconf-client-grouping
|         |         +---:(tls) {tls-initiate}?
|         |         +-- tls
|         |         +-- tcp-client-parameters
|         |         | +---u netconf-client-grouping
|         |         +-- tls-client-parameters
|         |         +---u netconf-client-grouping
| +-- connection-type
|   +-- (connection-type)
|     +---:(persistent-connection)
|       | +-- persistent!
|       +---:(periodic-connection)
|         +-- periodic!
|           +-- period?          uint16
|           +-- anchor-time?     yang:date-and-time
|           +-- idle-timeout?    uint16
| +-- reconnect-strategy
|   +-- start-with?      enumeration
|   +-- max-attempts?    uint8
+-- listen! {ssh-listen or tls-listen}?
  +-- idle-timeout?      uint16
  +-- endpoint* [name]
    +-- name?            string
    +-- (transport)
      +---:(ssh) {ssh-listen}?
        | +-- ssh
        |   +-- tcp-server-parameters
        |   | +---u netconf-client-grouping
        |   +-- ssh-client-parameters
        |   | +---u netconf-client-grouping
      +---:(tls) {tls-listen}?
        +-- tls
          +-- tcp-server-parameters
          | +---u netconf-client-grouping
          +-- tls-client-parameters
            +---u netconf-client-grouping

```

3.2. Example Usage

The following example illustrates configuring a NETCONF client to initiate connections, using both the SSH and TLS transport protocols, as well as listening for call-home connections, again using both the SSH and TLS transport protocols.

This example is consistent with the examples presented in Section 2 of [\[I-D.ietf-netconf-trust-anchors\]](#) and [Section 3.2](#) of [\[I-D.ietf-netconf-keystore\]](#).

===== NOTE: '\\' line wrapping per BCP XX (RFC XXXX) =====

```
<netconf-client
  xmlns="urn:ietf:params:xml:ns:yang:ietf-netconf-client">

  <!-- NETCONF servers to initiate connections to -->
  <initiate>
    <netconf-server>
      <name>corp-fw1</name>
      <endpoints>
        <endpoint>
          <name>corp-fw1.example.com</name>
          <ssh>
            <tcp-client-parameters>
              <remote-address>corp-fw1.example.com</remote-address>
              <keepalives>
                <idle-time>15</idle-time>
                <max-probes>3</max-probes>
                <probe-interval>30</probe-interval>
              </keepalives>
            </tcp-client-parameters>
            <ssh-client-parameters>
              <client-identity>
                <username>foobar</username>
                <public-key>
                  <local-definition>
                    <algorithm xmlns:ct="urn:ietf:params:xml:ns:yang\
:ietf-crypto-types">ct:rsa2048</algorithm>
                    <private-key>base64encodedvalue==</private-key>
                    <public-key>base64encodedvalue==</public-key>
                  </local-definition>
                </public-key>
              </client-identity>
              <server-authentication>
                <pinned-ca-certs>explicitly-trusted-server-ca-certs<\
/pinned-ca-certs>
                <pinned-server-certs>explicitly-trusted-server-certs\
</pinned-server-certs>
              </server-authentication>
              <keepalives>
                <max-wait>30</max-wait>
                <max-attempts>3</max-attempts>
              </keepalives>
            </ssh-client-parameters>
          </ssh>
        </endpoint>
        <endpoint>
          <name>corp-fw2.example.com</name>
```

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```
<ssh>
  <tcp-client-parameters>
    <remote-address>corp-fw2.example.com</remote-address>
    <keepalives>
      <idle-time>15</idle-time>
      <max-probes>3</max-probes>
      <probe-interval>30</probe-interval>
    </keepalives>
  </tcp-client-parameters>
  <ssh-client-parameters>
    <client-identity>
      <username>foobar</username>
      <public-key>
        <local-definition>
          <algorithm xmlns:ct="urn:ietf:params:xml:ns:yang\
:ietf-crypto-types">ct:rsa2048</algorithm>
          <private-key>base64encodedvalue==</private-key>
          <public-key>base64encodedvalue==</public-key>
        </local-definition>
      </public-key>
    </client-identity>
    <server-authentication>
      <pinned-ca-certs>explicitly-trusted-server-ca-certs<\
/pinned-ca-certs>
      <pinned-server-certs>explicitly-trusted-server-certs\
</pinned-server-certs>
    </server-authentication>
    <keepalives>
      <max-wait>30</max-wait>
      <max-attempts>3</max-attempts>
    </keepalives>
  </ssh-client-parameters>
</ssh>
</endpoint>
</endpoints>
<connection-type>
  <persistent/>
</connection-type>
<reconnect-strategy>
  <start-with>last-connected</start-with>
</reconnect-strategy>
</netconf-server>
</initiate>

<!-- endpoints to listen for NETCONF Call Home connections on -->
<listen>
  <endpoint>
    <name>Intranet-facing listener</name>
```

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```

<ssh>
  <tcp-server-parameters>
    <local-address>192.0.2.7</local-address>
  </tcp-server-parameters>
  <ssh-client-parameters>
    <client-identity>
      <username>foobar</username>
      <public-key>
        <local-definition>
          <algorithm xmlns:ct="urn:ietf:params:xml:ns:yang:ietf-crypto-types">ct:rsa2048</algorithm>
          <private-key>base64encodedvalue==</private-key>
          <public-key>base64encodedvalue==</public-key>
        </local-definition>
      </public-key>
    </client-identity>
    <server-authentication>
      <pinned-ca-certs>explicitly-trusted-server-ca-certs</pinned-ca-certs>
      <pinned-server-certs>explicitly-trusted-server-certs</pinned-server-certs>
      <pinned-ssh-host-keys>explicitly-trusted-ssh-host-keys</pinned-ssh-host-keys>
    </server-authentication>
  </ssh-client-parameters>
</ssh>
</endpoint>
</listen>
</netconf-client>

```

3.3. YANG Module

This YANG module has normative references to [\[RFC6242\]](#), [\[RFC6991\]](#), [\[RFC7589\]](#), [\[RFC8071\]](#), [\[I-D.kwatsen-netconf-tcp-client-server\]](#), [\[I-D.ietf-netconf-ssh-client-server\]](#), and [\[I-D.ietf-netconf-tls-client-server\]](#).

```

<CODE BEGINS> file "ietf-netconf-client@2019-04-29.yang"
module ietf-netconf-client {
  yang-version 1.1;
  namespace "urn:ietf:params:xml:ns:yang:ietf-netconf-client";
  prefix ncc;

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

```



```
import ietf-tcp-client {
  prefix tcpc;
  reference
    "RFC AAAA: YANG Groupings for TCP Clients and TCP Servers";
}
import ietf-tcp-server {
  prefix tcps;
  reference
    "RFC AAAA: YANG Groupings for TCP Clients and TCP Servers";
}

import ietf-ssh-client {
  prefix sshc;
  revision-date 2019-04-29; // stable grouping definitions
  reference
    "RFC BBBB: YANG Groupings for SSH Clients and SSH Servers";
}

import ietf-tls-client {
  prefix tlsc;
  revision-date 2019-04-29; // stable grouping definitions
  reference
    "RFC CCCC: YANG Groupings for TLS Clients and TLS Servers";
}

organization
  "IETF NETCONF (Network Configuration) Working Group";

contact
  "WG Web:   <http://datatracker.ietf.org/wg/netconf/>
  WG List:  <mailto:netconf@ietf.org>
  Author:   Kent Watsen <mailto:kent+ietf@watsen.net>
  Author:   Gary Wu <mailto:garywu@cisco.com>";

description
  "This module contains a collection of YANG definitions
  for configuring NETCONF clients.

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```


This version of this YANG module is part of RFC XXXX (<https://www.rfc-editor.org/info/rfcXXXX>); see the RFC itself for full legal notices.;

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```
revision 2019-04-29 {
  description
    "Initial version";
  reference
    "RFC XXXX: NETCONF Client and Server Models";
}

// Features

feature ssh-initiate {
  description
    "The 'ssh-initiate' feature indicates that the NETCONF client
    supports initiating SSH connections to NETCONF servers.";
  reference
    "RFC 6242:
    Using the NETCONF Protocol over Secure Shell (SSH)";
}

feature tls-initiate {
  description
    "The 'tls-initiate' feature indicates that the NETCONF client
    supports initiating TLS connections to NETCONF servers.";
  reference
    "RFC 7589: Using the NETCONF Protocol over Transport
    Layer Security (TLS) with Mutual X.509 Authentication";
}

feature ssh-listen {
  description
    "The 'ssh-listen' feature indicates that the NETCONF client
    supports opening a port to listen for incoming NETCONF
    server call-home SSH connections.";
  reference
    "RFC 8071: NETCONF Call Home and RESTCONF Call Home";
}

feature tls-listen {
```



```
description
  "The 'tls-listen' feature indicates that the NETCONF client
  supports opening a port to listen for incoming NETCONF
  server call-home TLS connections.";
reference
  "RFC 8071: NETCONF Call Home and RESTCONF Call Home";
}

// Groupings

grouping netconf-client-grouping {
  description
    "Top-level grouping for NETCONF client configuration.";
  container initiate {
    if-feature "ssh-initiate or tls-initiate";
    presence "Enables client to initiate TCP connections";
    description
      "Configures client initiating underlying TCP connections.";
    list netconf-server {
      key "name";
      min-elements 1;
      description
        "List of NETCONF servers the NETCONF client is to
        initiate connections to in parallel.";
      leaf name {
        type string;
        description
          "An arbitrary name for the NETCONF server.";
      }
    }
    container endpoints {
      description
        "Container for the list of endpoints.";
      list endpoint {
        key "name";
        min-elements 1;
        ordered-by user;
        description
          "A user-ordered list of endpoints that the NETCONF
          client will attempt to connect to in the specified
          sequence. Defining more than one enables
          high-availability.";
        leaf name {
          type string;
          description
            "An arbitrary name for the endpoint.";
        }
      }
      choice transport {
        mandatory true;
      }
    }
  }
}
```

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```
description
  "Selects between available transports.";
case ssh {
  if-feature "ssh-initiate";
  container ssh {
    description
      "Specifies IP and SSH specific configuration
      for the connection.";
    container tcp-client-parameters {
      description
        "A wrapper around the TCP client parameters
        to avoid name collisions.";
      uses tcpc:tcp-client-grouping {
        refine "remote-port" {
          default "830";
          description
            "The NETCONF client will attempt to connect
            to the IANA-assigned well-known port value
            for 'netconf-ssh' (443) if no value is
            specified.";
        }
      }
    }
    container ssh-client-parameters {
      description
        "A wrapper around the SSH client parameters to
        avoid name collisions.";
      uses sshc:ssh-client-grouping;
    }
  }
}
case tls {
  if-feature "tls-initiate";
  container tls {
    description
      "Specifies IP and TLS specific configuration
      for the connection.";
    container tcp-client-parameters {
      description
        "A wrapper around the TCP client parameters
        to avoid name collisions.";
      uses tcpc:tcp-client-grouping {
        refine "remote-port" {
          default "6513";
          description
            "The NETCONF client will attempt to connect
            to the IANA-assigned well-known port value
            for 'netconf-tls' (6513) if no value is
```

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```
        specified.";
    }
}
}
container tls-client-parameters {
    description
        "A wrapper around the TLS client parameters
        to avoid name collisions.";
    uses tlsc:tls-client-grouping {
        refine "client-identity"
                                + "/auth-type" {
            mandatory true;
            description
                "NETCONF/TLS clients MUST pass some
                authentication credentials.";
        }
    }
}
} // choice transport
} // list endpoint
} // container endpoints

container connection-type {
    description
        "Indicates the NETCONF client's preference for how the
        NETCONF connection is maintained.";
    choice connection-type {
        mandatory true;
        description
            "Selects between available connection types.";
        case persistent-connection {
            container persistent {
                presence "Indicates that a persistent connection is
                to be maintained.";
                description
                    "Maintain a persistent connection to the NETCONF
                    server. If the connection goes down, immediately
                    start trying to reconnect to the NETCONF server,
                    using the reconnection strategy.

                    This connection type minimizes any NETCONF server
                    to NETCONF client data-transfer delay, albeit at
                    the expense of holding resources longer.";
            }
        }
        case periodic-connection {
```



```
container periodic {
  presence "Indicates that a periodic connection is
           to be maintained.";
  description
    "Periodically connect to the NETCONF server.

    This connection type increases resource
    utilization, albeit with increased delay in
    NETCONF server to NETCONF client interactions.

    The NETCONF client should close the underlying
    TCP connection upon completing planned activities.

    In the case that the previous connection is still
    active, establishing a new connection is NOT
    RECOMMENDED.";
  leaf period {
    type uint16;
    units "minutes";
    default "60";
    description
      "Duration of time between periodic connections.";
  }
  leaf anchor-time {
    type yang:date-and-time {
      // constrained to minute-level granularity
      pattern '\d{4}-\d{2}-\d{2}T\d{2}:\d{2}'
        + '(Z|[\+\-]\d{2}:\d{2})';
    }
    description
      "Designates a timestamp before or after which a
       series of periodic connections are determined.
       The periodic connections occur at a whole
       multiple interval from the anchor time. For
       example, for an anchor time is 15 minutes past
       midnight and a period interval of 24 hours, then
       a periodic connection will occur 15 minutes past
       midnight everyday.";
  }
  leaf idle-timeout {
    type uint16;
    units "seconds";
    default 120; // two minutes
    description
      "Specifies the maximum number of seconds that
       a NETCONF session may remain idle. A NETCONF
       session will be dropped if it is idle for an
       interval longer then this number of seconds.
```

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```
        If set to zero, then the NETCONF client will
        never drop a session because it is idle.";
    }
}
}
}
}
container reconnect-strategy {
  description
    "The reconnection strategy directs how a NETCONF client
    reconnects to a NETCONF server, after discovering its
    connection to the server has dropped, even if due to a
    reboot. The NETCONF client starts with the specified
    endpoint and tries to connect to it max-attempts times
    before trying the next endpoint in the list (round
    robin).";
  leaf start-with {
    type enumeration {
      enum first-listed {
        description
          "Indicates that reconnections should start with
          the first endpoint listed.";
      }
      enum last-connected {
        description
          "Indicates that reconnections should start with
          the endpoint last connected to. If no previous
          connection has ever been established, then the
          first endpoint configured is used. NETCONF
          clients SHOULD be able to remember the last
          endpoint connected to across reboots.";
      }
      enum random-selection {
        description
          "Indicates that reconnections should start with
          a random endpoint.";
      }
    }
    default "first-listed";
    description
      "Specifies which of the NETCONF server's endpoints
      the NETCONF client should start with when trying
      to connect to the NETCONF server.";
  }
  leaf max-attempts {
    type uint8 {
      range "1..max";
    }
  }
}
```



```
        default "3";
        description
            "Specifies the number times the NETCONF client tries
             to connect to a specific endpoint before moving on
             to the next endpoint in the list (round robin).";
    }
}
} // netconf-server
} // initiate

container listen {
    if-feature "ssh-listen or tls-listen";
    presence "Enables client to accept call-home connections";
    description
        "Configures client accepting call-home TCP connections.";
    leaf idle-timeout {
        type uint16;
        units "seconds";
        default "3600"; // one hour
        description
            "Specifies the maximum number of seconds that a NETCONF
             session may remain idle. A NETCONF session will be
             dropped if it is idle for an interval longer than this
             number of seconds. If set to zero, then the server
             will never drop a session because it is idle. Sessions
             that have a notification subscription active are never
             dropped.";
    }
    list endpoint {
        key "name";
        min-elements 1;
        description
            "List of endpoints to listen for NETCONF connections.";
        leaf name {
            type string;
            description
                "An arbitrary name for the NETCONF listen endpoint.";
        }
    }
    choice transport {
        mandatory true;
        description
            "Selects between available transports.";
        case ssh {
            if-feature "ssh-listen";
            container ssh {
                description
                    "SSH-specific listening configuration for inbound
                     connections.";
            }
        }
    }
}
```



```
    container tcp-server-parameters {
      description
        "A wrapper around the TCP server parameters
        to avoid name collisions.";
      uses tcps:tcp-server-grouping {
        refine "local-port" {
          default "4334";
          description
            "The NETCONF client will listen on the IANA-
            assigned well-known port for 'netconf-ch-ssh'
            (4334) if no value is specified.";
        }
      }
    }
  }
  container ssh-client-parameters {
    description
      "A wrapper around the SSH client parameters
      to avoid name collisions.";
    uses sshc:ssh-client-grouping;
  }
}

case tls {
  if-feature "tls-listen";
  container tls {
    description
      "TLS-specific listening configuration for inbound
      connections.";
    container tcp-server-parameters {
      description
        "A wrapper around the TCP server parameters
        to avoid name collisions.";
      uses tcps:tcp-server-grouping {
        refine "local-port" {
          default "4334";
          description
            "The NETCONF client will listen on the IANA-
            assigned well-known port for 'netconf-ch-ssh'
            (4334) if no value is specified.";
        }
      }
    }
  }
}
  container tls-client-parameters {
    description
      "A wrapper around the TLS client parameters
      to avoid name collisions.";
    uses tlsc:tls-client-grouping {
      refine "client-identity/auth-type" {
```



```
        mandatory true;
        description
            "NETCONF/TLS clients MUST pass some
             authentication credentials.";
    }
}
}
}
} // transport
} // endpoint
} // listen
} // netconf-client

// Protocol accessible node, for servers that implement this
// module.

container netconf-client {
    uses netconf-client-grouping;
    description
        "Top-level container for NETCONF client configuration.";
}
}
<CODE ENDS>
```

4. The NETCONF Server Model

The NETCONF server model presented in this section supports both listening for connections as well as initiating call-home connections, using either the SSH and TLS transport protocols.

YANG feature statements are used to enable implementations to advertise which potentially uncommon parts of the model the NETCONF server supports.

4.1. Tree Diagram

The following tree diagram [[RFC8340](#)] provides an overview of the data model for the "ietf-netconf-server" module.

This tree diagram only shows the nodes defined in this module; it does show the nodes defined by "grouping" statements used by this module.

Please see [Appendix A.2](#) for a tree diagram that illustrates what the module looks like with all the "grouping" statements expanded.

module: ietf-netconf-server


```

+--rw netconf-server
  +---u netconf-server-grouping

grouping netconf-server-grouping
  +-- listen! {ssh-listen or tls-listen}?
  | +-- idle-timeout?   uint16
  | +-- endpoint* [name]
  |   +-- name?        string
  |   +-- (transport)
  |     +--:(ssh) {ssh-listen}?
  |     | +-- ssh
  |     |   +-- tcp-server-parameters
  |     |   | +---u netconf-server-grouping
  |     |   +-- ssh-server-parameters
  |     |   | +---u netconf-server-grouping
  |     +--:(tls) {tls-listen}?
  |     | +-- tls
  |     |   +-- tcp-server-parameters
  |     |   | +---u netconf-server-grouping
  |     |   +-- tls-server-parameters
  |     |   | +---u netconf-server-grouping
  +-- call-home! {ssh-call-home or tls-call-home}?
  +-- netconf-client* [name]
  |   +-- name?          string
  |   +-- endpoints
  |     +-- endpoint* [name]
  |     | +-- name?      string
  |     | +-- (transport)
  |     |   +--:(ssh) {ssh-call-home}?
  |     |   | +-- ssh
  |     |   |   +-- tcp-client-parameters
  |     |   |   | +---u netconf-server-grouping
  |     |   |   +-- ssh-server-parameters
  |     |   |   | +---u netconf-server-grouping
  |     |   +--:(tls) {tls-call-home}?
  |     |   | +-- tls
  |     |   |   +-- tcp-client-parameters
  |     |   |   | +---u netconf-server-grouping
  |     |   |   +-- tls-server-parameters
  |     |   |   | +---u netconf-server-grouping
  +-- connection-type
  | +-- (connection-type)
  |   +--:(persistent-connection)
  |   | +-- persistent!
  |   +--:(periodic-connection)
  |   | +-- periodic!
  |   |   +-- period?      uint16
  |   |   +-- anchor-time? yang:date-and-time

```



```

|           +-- idle-timeout?   uint16
+-- reconnect-strategy
|   +-- start-with?             enumeration
|   +-- max-attempts?          uint8

```

4.2. Example Usage

The following example illustrates configuring a NETCONF server to listen for NETCONF client connections using both the SSH and TLS transport protocols, as well as configuring call-home to two NETCONF clients, one using SSH and the other using TLS.

This example is consistent with the examples presented in Section 2 of [[I-D.ietf-netconf-trust-anchors](#)] and [Section 3.2](#) of [[I-D.ietf-netconf-keystore](#)].

===== NOTE: '\ ' line wrapping per BCP XX (RFC XXXX) =====

```

<netconf-server
  xmlns="urn:ietf:params:xml:ns:yang:ietf-netconf-server"
  xmlns:x509c2n="urn:ietf:params:xml:ns:yang:ietf-x509-cert-to-name">

  <!-- endpoints to listen for NETCONF connections on -->
  <listen>
    <endpoint> <!-- listening for SSH connections -->
      <name>netconf/ssh</name>
      <ssh>
        <tcp-server-parameters>
          <local-address>192.0.2.7</local-address>
        </tcp-server-parameters>
        <ssh-server-parameters>
          <server-identity>
            <host-key>
              <name>deployment-specific-certificate</name>
              <public-key>
                <local-definition>
                  <algorithm xmlns:ct="urn:ietf:params:xml:ns:yang:ietf-crypto-types">ct:rsa2048</algorithm>
                  <private-key>base64encodedvalue==</private-key>
                  <public-key>base64encodedvalue==</public-key>
                </local-definition>
              </public-key>
            </host-key>
          </server-identity>
          <client-authentication>
            <supported-authentication-methods>
              <publickey/>
            </supported-authentication-methods>

```



```

        <client-auth-defined-elsewhere/>
      </client-authentication>
    </ssh-server-parameters>
  </ssh>
</endpoint>
<endpoint> <!-- listening for TLS sessions -->
  <name>netconf/tls</name>
  <tls>
    <tcp-server-parameters>
      <local-address>192.0.2.7</local-address>
    </tcp-server-parameters>
    <tls-server-parameters>
      <server-identity>
        <local-definition>
          <algorithm xmlns:ct="urn:ietf:params:xml:ns:yang:ietf-
crypto-types">ct:rsa2048</algorithm>
          <private-key>base64encodedvalue==</private-key>
          <public-key>base64encodedvalue==</public-key>
          <cert>base64encodedvalue==</cert>
        </local-definition>
      </server-identity>
      <client-authentication>
        <required/>
        <pinned-ca-certs>explicitly-trusted-client-ca-certs</pin\
ned-ca-certs>
        <pinned-client-certs>explicitly-trusted-client-certs</pi\
nned-client-certs>
        <cert-maps>
          <cert-to-name>
            <id>1</id>
            <fingerprint>11:0A:05:11:00</fingerprint>
            <map-type>x509c2n:san-any</map-type>
          </cert-to-name>
          <cert-to-name>
            <id>2</id>
            <fingerprint>B3:4F:A1:8C:54</fingerprint>
            <map-type>x509c2n:specified</map-type>
            <name>scooby-doo</name>
          </cert-to-name>
        </cert-maps>
      </client-authentication>
    </tls-server-parameters>
  </tls>
</endpoint>
</listen>

<!-- calling home to SSH and TLS based NETCONF clients -->
<call-home>

```



```

<netconf-client> <!-- SSH-based client -->
  <name>config-mgr</name>
  <endpoints>
    <endpoint>
      <name>east-data-center</name>
      <ssh>
        <tcp-client-parameters>
          <remote-address>east.config-mgr.example.com</remote-ad\
dress>
        </tcp-client-parameters>
        <ssh-server-parameters>
          <server-identity>
            <host-key>
              <name>deployment-specific-certificate</name>
              <public-key>
                <local-definition>
                  <algorithm xmlns:ct="urn:ietf:params:xml:ns:ya\
ng:ietf-crypto-types">ct:rsa2048</algorithm>
                  <private-key>base64encodedvalue==</private-key>
                  <public-key>base64encodedvalue==</public-key>
                </local-definition>
              </public-key>
            </host-key>
          </server-identity>
          <client-authentication>
            <supported-authentication-methods>
              <publickey/>
            </supported-authentication-methods>
            <client-auth-defined-elsewhere/>
          </client-authentication>
        </ssh-server-parameters>
      </ssh>
    </endpoint>
    <endpoint>
      <name>west-data-center</name>
      <ssh>
        <tcp-client-parameters>
          <remote-address>west.config-mgr.example.com</remote-ad\
dress>
        </tcp-client-parameters>
        <ssh-server-parameters>
          <server-identity>
            <host-key>
              <name>deployment-specific-certificate</name>
              <public-key>
                <local-definition>
                  <algorithm xmlns:ct="urn:ietf:params:xml:ns:ya\
ng:ietf-crypto-types">ct:rsa2048</algorithm>

```



```

        <private-key>base64encodedvalue==</private-key>
        <public-key>base64encodedvalue==</public-key>
    </local-definition>
</public-key>
</host-key>
</server-identity>
<client-authentication>
    <supported-authentication-methods>
        <publickey/>
    </supported-authentication-methods>
    <client-auth-defined-elsewhere/>
</client-authentication>
</ssh-server-parameters>
</ssh>
</endpoint>
</endpoints>
<connection-type>
    <periodic>
        <idle-timeout>300</idle-timeout>
        <period>60</period>
    </periodic>
</connection-type>
<reconnect-strategy>
    <start-with>last-connected</start-with>
    <max-attempts>3</max-attempts>
</reconnect-strategy>
</netconf-client>
<netconf-client> <!-- TLS-based client -->
    <name>data-collector</name>
    <endpoints>
        <endpoint>
            <name>east-data-center</name>
            <tls>
                <tcp-client-parameters>
                    <remote-address>east.analytics.example.com</remote-add\
ress>

                <keepalives>
                    <idle-time>15</idle-time>
                    <max-probes>3</max-probes>
                    <probe-interval>30</probe-interval>
                </keepalives>
            </tcp-client-parameters>
            <tls-server-parameters>
                <server-identity>
                    <local-definition>
                        <algorithm xmlns:ct="urn:ietf:params:xml:ns:yang:i\
ietf-crypto-types">ct:rsa2048</algorithm>
                        <private-key>base64encodedvalue==</private-key>

```



```

        <public-key>base64encodedvalue==</public-key>
        <cert>base64encodedvalue==</cert>
    </local-definition>
</server-identity>
<client-authentication>
    <required/>
    <pinned-ca-certs>explicitly-trusted-client-ca-certs<\
/pinned-ca-certs>
    <pinned-client-certs>explicitly-trusted-client-certs\
</pinned-client-certs>
    <cert-maps>
        <cert-to-name>
            <id>1</id>
            <fingerprint>11:0A:05:11:00</fingerprint>
            <map-type>x509c2n:san-any</map-type>
        </cert-to-name>
        <cert-to-name>
            <id>2</id>
            <fingerprint>B3:4F:A1:8C:54</fingerprint>
            <map-type>x509c2n:specified</map-type>
            <name>scooby-doo</name>
        </cert-to-name>
    </cert-maps>
</client-authentication>
<keepalives>
    <max-wait>30</max-wait>
    <max-attempts>3</max-attempts>
</keepalives>
</tls-server-parameters>
</tls>
</endpoint>
<endpoint>
    <name>west-data-center</name>
    <tls>
        <tcp-client-parameters>
            <remote-address>west.analytics.example.com</remote-add\
ress>
            <keepalives>
                <idle-time>15</idle-time>
                <max-probes>3</max-probes>
                <probe-interval>30</probe-interval>
            </keepalives>
        </tcp-client-parameters>
        <tls-server-parameters>
            <server-identity>
                <local-definition>
                    <algorithm xmlns:ct="urn:ietf:params:xml:ns:yang:i\
ietf-crypto-types">ct:rsa2048</algorithm>

```

Watsen

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```
        <private-key>base64encodedvalue==</private-key>
        <public-key>base64encodedvalue==</public-key>
        <cert>base64encodedvalue==</cert>
    </local-definition>
</server-identity>
<client-authentication>
    <required/>
    <pinned-ca-certs>explicitly-trusted-client-ca-certs<\
/pinned-ca-certs>
    <pinned-client-certs>explicitly-trusted-client-certs\
</pinned-client-certs>
    <cert-maps>
        <cert-to-name>
            <id>1</id>
            <fingerprint>11:0A:05:11:00</fingerprint>
            <map-type>x509c2n:san-any</map-type>
        </cert-to-name>
        <cert-to-name>
            <id>2</id>
            <fingerprint>B3:4F:A1:8C:54</fingerprint>
            <map-type>x509c2n:specified</map-type>
            <name>scooby-doo</name>
        </cert-to-name>
    </cert-maps>
</client-authentication>
<keepalives>
    <max-wait>30</max-wait>
    <max-attempts>3</max-attempts>
</keepalives>
</tls-server-parameters>
</tls>
</endpoint>
</endpoints>
<connection-type>
    <persistent/>
</connection-type>
<reconnect-strategy>
    <start-with>first-listed</start-with>
    <max-attempts>3</max-attempts>
</reconnect-strategy>
</netconf-client>
</call-home>
</netconf-server>
```


4.3. YANG Module

This YANG module has normative references to [\[RFC6242\]](#), [\[RFC6991\]](#), [\[RFC7407\]](#), [\[RFC7589\]](#), [\[RFC8071\]](#), [\[I-D.kwatsen-netconf-tcp-client-server\]](#), [\[I-D.ietf-netconf-ssh-client-server\]](#), and [\[I-D.ietf-netconf-tls-client-server\]](#).

```
<CODE BEGINS> file "ietf-netconf-server@2019-04-29.yang"
module ietf-netconf-server {
  yang-version 1.1;
  namespace "urn:ietf:params:xml:ns:yang:ietf-netconf-server";
  prefix ncs;

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

  import ietf-x509-cert-to-name {
    prefix x509c2n;
    reference
      "RFC 7407: A YANG Data Model for SNMP Configuration";
  }

  import ietf-tcp-client {
    prefix tcpc;
    reference
      "RFC AAAA: YANG Groupings for TCP Clients and TCP Servers";
  }

  import ietf-tcp-server {
    prefix tcps;
    reference
      "RFC AAAA: YANG Groupings for TCP Clients and TCP Servers";
  }

  import ietf-ssh-server {
    prefix sshs;
    revision-date 2019-04-29; // stable grouping definitions
    reference
      "RFC BBBB: YANG Groupings for SSH Clients and SSH Servers";
  }

  import ietf-tls-server {
    prefix tlss;
    revision-date 2019-04-29; // stable grouping definitions
```



```
reference
  "RFC CCCC: YANG Groupings for TLS Clients and TLS Servers";
}
```

```
organization
  "IETF NETCONF (Network Configuration) Working Group";
```

```
contact
  "WG Web:    <http://datatracker.ietf.org/wg/netconf/>
  WG List:    <mailto:netconf@ietf.org>
  Author:     Kent Watsen <mailto:kent+ietf@watsen.net>
  Author:     Gary Wu <mailto:garywu@cisco.com>
  Author:     Juergen Schoenwaelder
               <mailto:j.schoenwaelder@jacobs-university.de>";
```

```
description
  "This module contains a collection of YANG definitions
  for configuring NETCONF servers.
```

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as authors of the code. All rights reserved.

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BSD License set forth in [Section 4.c](#) of the IETF Trust's
Legal Provisions Relating to IETF Documents
(<https://trustee.ietf.org/license-info>).

This version of this YANG module is part of RFC XXXX
(<https://www.rfc-editor.org/info/rfcXXXX>); see the RFC
itself for full legal notices.;

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.";

```
revision 2019-04-29 {
  description
    "Initial version";
  reference
    "RFC XXXX: NETCONF Client and Server Models";
}
```

```
// Features
```



```
feature ssh-listen {
  description
    "The 'ssh-listen' feature indicates that the NETCONF server
    supports opening a port to accept NETCONF over SSH
    client connections.";
  reference
    "RFC 6242:
    Using the NETCONF Protocol over Secure Shell (SSH)";
}

feature tls-listen {
  description
    "The 'tls-listen' feature indicates that the NETCONF server
    supports opening a port to accept NETCONF over TLS
    client connections.";
  reference
    "RFC 7589: Using the NETCONF Protocol over Transport
    Layer Security (TLS) with Mutual X.509
    Authentication";
}

feature ssh-call-home {
  description
    "The 'ssh-call-home' feature indicates that the NETCONF
    server supports initiating a NETCONF over SSH call
    home connection to NETCONF clients.";
  reference
    "RFC 8071: NETCONF Call Home and RESTCONF Call Home";
}

feature tls-call-home {
  description
    "The 'tls-call-home' feature indicates that the NETCONF
    server supports initiating a NETCONF over TLS call
    home connection to NETCONF clients.";
  reference
    "RFC 8071: NETCONF Call Home and RESTCONF Call Home";
}

// Groupings

grouping netconf-server-grouping {
  description
    "Top-level grouping for NETCONF server configuration.";
  container listen {
    if-feature "ssh-listen or tls-listen";
    presence
      "Enables server to listen for NETCONF client connections.";
  }
}
```



```
description
  "Configures listen behavior";
leaf idle-timeout {
  type uint16;
  units "seconds";
  default 3600; // one hour
  description
    "Specifies the maximum number of seconds that a NETCONF
    session may remain idle. A NETCONF session will be
    dropped if it is idle for an interval longer than this
    number of seconds. If set to zero, then the server
    will never drop a session because it is idle. Sessions
    that have a notification subscription active are never
    dropped.";
}
list endpoint {
  key "name";
  min-elements 1;
  description
    "List of endpoints to listen for NETCONF connections.";
  leaf name {
    type string;
    description
      "An arbitrary name for the NETCONF listen endpoint.";
  }
  choice transport {
    mandatory true;
    description
      "Selects between available transports.";
    case ssh {
      if-feature "ssh-listen";
      container ssh {
        description
          "SSH-specific listening configuration for inbound
          connections.";
        container tcp-server-parameters {
          description
            "A wrapper around the TCP client parameters
            to avoid name collisions.";
          uses tcps:tcp-server-grouping {
            refine "local-port" {
              default "830";
              description
                "The NETCONF server will listen on the
                IANA-assigned well-known port value
                for 'netconf-ssh' (830) if no value
                is specified.";
            }
          }
        }
      }
    }
  }
}
```



```
    }
  }
  container ssh-server-parameters {
    description
      "A wrapper around the SSH server parameters
      to avoid name collisions.";
    uses sshs:ssh-server-grouping;
  }
}
case tls {
  if-feature "tls-listen";
  container tls {
    description
      "TLS-specific listening configuration for inbound
      connections.";
    container tcp-server-parameters {
      description
        "A wrapper around the TCP client parameters
        to avoid name collisions.";
      uses tcps:tcp-server-grouping {
        refine "local-port" {
          default "6513";
          description
            "The NETCONF server will listen on the
            IANA-assigned well-known port value
            for 'netconf-tls' (6513) if no value
            is specified.";
        }
      }
    }
  }
}
container tls-server-parameters {
  description
    "A wrapper around the TLS server parameters to
    avoid name collisions.";
  uses tlss:tls-server-grouping {
    refine "client-authentication" {
      //must 'pinned-ca-certs or pinned-client-certs';
      description
        "NETCONF/TLS servers MUST validate client
        certificates.";
    }
    augment "client-authentication" {
      description
        "Augments in the cert-to-name structure.";
      container cert-maps {
        uses x509c2n:cert-to-name;
        description
```



```
        "The cert-maps container is used by a TLS-
        based NETCONF server to map the NETCONF
        client's presented X.509 certificate to
        a NETCONF username.  If no matching and
        valid cert-to-name list entry can be found,
        then the NETCONF server MUST close the
        connection, and MUST NOT accept NETCONF
        messages over it.";
    reference
        "RFC WWW: NETCONF over TLS, Section 7";
    }
  }
}

container call-home {
  if-feature "ssh-call-home or tls-call-home";
  presence
    "Enables the NETCONF server to initiate the underlying
    transport connection to NETCONF clients.";
  description "Configures call home behavior.";
  list netconf-client {
    key "name";
    min-elements 1;
    description
      "List of NETCONF clients the NETCONF server is to
      initiate call-home connections to in parallel.";
    leaf name {
      type string;
      description
        "An arbitrary name for the remote NETCONF client.";
    }
  }
  container endpoints {
    description
      "Container for the list of endpoints.";
    list endpoint {
      key "name";
      min-elements 1;
      ordered-by user;
      description
        "A non-empty user-ordered list of endpoints for this
        NETCONF server to try to connect to in sequence.
        Defining more than one enables high-availability.";
      leaf name {
```



```
    type string;
    description
        "An arbitrary name for this endpoint.";
}
choice transport {
    mandatory true;
    description
        "Selects between available transports.";
    case ssh {
        if-feature "ssh-call-home";
        container ssh {
            description
                "Specifies SSH-specific call-home transport
                configuration.";
            container tcp-client-parameters {
                description
                    "A wrapper around the TCP client parameters
                    to avoid name collisions.";
                uses tcpc:tcp-client-grouping {
                    refine "remote-port" {
                        default "4334";
                        description
                            "The NETCONF server will attempt to connect
                            to the IANA-assigned well-known port for
                            'netconf-ch-tls' (4334) if no value is
                            specified.";
                    }
                }
            }
        }
        container ssh-server-parameters {
            description
                "A wrapper around the SSH server parameters
                to avoid name collisions.";
            uses sshs:ssh-server-grouping;
        }
    }
}
case tls {
    if-feature "tls-call-home";
    container tls {
        description
            "Specifies TLS-specific call-home transport
            configuration.";
        container tcp-client-parameters {
            description
                "A wrapper around the TCP client parameters
                to avoid name collisions.";
            uses tcpc:tcp-client-grouping {
```



```
        refine "remote-port" {
            default "4335";
            description
                "The NETCONF server will attempt to connect
                 to the IANA-assigned well-known port for
                 'netconf-ch-tls' (4335) if no value is
                 specified.";
        }
    }
}

container tls-server-parameters {
    description
        "A wrapper around the TLS server parameters
         to avoid name collisions.";
    uses tlss:tls-server-grouping {
        refine "client-authentication" {
            /* commented out since auth could be external
             must 'pinned-ca-certs or pinned-client-certs';
            */
            description
                "NETCONF/TLS servers MUST validate client
                 certificates.";
        }
        augment "client-authentication" {
            description
                "Augments in the cert-to-name structure.";
            container cert-maps {
                uses x509c2n:cert-to-name;
                description
                    "The cert-maps container is used by a
                     TLS-based NETCONF server to map the
                     NETCONF client's presented X.509
                     certificate to a NETCONF username.  If
                     no matching and valid cert-to-name list
                     entry can be found, then the NETCONF
                     server MUST close the connection, and
                     MUST NOT accept NETCONF messages over
                     it.";
                reference
                    "RFC WWW: NETCONF over TLS, Section 7";
            }
        }
    }
}

} // tls
} // choice
} // endpoint
```



```
} // endpoints
container connection-type {
  description
    "Indicates the NETCONF server's preference for how the
    NETCONF connection is maintained.";
  choice connection-type {
    mandatory true;
    description
      "Selects between available connection types.";
    case persistent-connection {
      container persistent {
        presence "Indicates that a persistent connection is
        to be maintained.";
        description
          "Maintain a persistent connection to the NETCONF
          client. If the connection goes down, immediately
          start trying to reconnect to the NETCONF client,
          using the reconnection strategy.

          This connection type minimizes any NETCONF client
          to NETCONF server data-transfer delay, albeit at
          the expense of holding resources longer.";
      } // container persistent
    } // case persistent-connection
    case periodic-connection {
      container periodic {
        presence "Indicates that a periodic connection is
        to be maintained.";
        description
          "Periodically connect to the NETCONF client.

          This connection type increases resource
          utilization, albeit with increased delay in
          NETCONF client to NETCONF client interactions.

          The NETCONF client SHOULD gracefully close the
          connection using <close-session> upon completing
          planned activities. If the NETCONF session is
          not closed gracefully, the NETCONF server MUST
          immediately attempt to reestablish the connection.

          In the case that the previous connection is still
          active (i.e., the NETCONF client has not closed
          it yet), establishing a new connection is NOT
          RECOMMENDED.";
      } // container periodic
    } // case periodic-connection
  } // choice connection-type
}
```



```
        default "60";
        description
            "Duration of time between periodic connections.";
    }
    leaf anchor-time {
        type yang:date-and-time {
            // constrained to minute-level granularity
            pattern '\d{4}-\d{2}-\d{2}T\d{2}:\d{2}'
                + '(Z|[\+|-]\d{2}:\d{2})';
        }
        description
            "Designates a timestamp before or after which a
            series of periodic connections are determined.
            The periodic connections occur at a whole
            multiple interval from the anchor time. For
            example, for an anchor time is 15 minutes past
            midnight and a period interval of 24 hours, then
            a periodic connection will occur 15 minutes past
            midnight everyday.";
    }
    leaf idle-timeout {
        type uint16;
        units "seconds";
        default 120; // two minutes
        description
            "Specifies the maximum number of seconds that
            a NETCONF session may remain idle. A NETCONF
            session will be dropped if it is idle for an
            interval longer than this number of seconds.
            If set to zero, then the server will never
            drop a session because it is idle.";
    }
} // container periodic
} // case periodic-connection
} // choice connection-type
} // container connection-type
container reconnect-strategy {
    description
        "The reconnection strategy directs how a NETCONF server
        reconnects to a NETCONF client, after discovering its
        connection to the client has dropped, even if due to a
        reboot. The NETCONF server starts with the specified
        endpoint and tries to connect to it max-attempts times
        before trying the next endpoint in the list (round
        robin).";
    leaf start-with {
        type enumeration {
            enum first-listed {
```



```
        description
            "Indicates that reconnections should start with
            the first endpoint listed.";
    }
    enum last-connected {
        description
            "Indicates that reconnections should start with
            the endpoint last connected to.  If no previous
            connection has ever been established, then the
            first endpoint configured is used.  NETCONF
            servers SHOULD be able to remember the last
            endpoint connected to across reboots.";
    }
    enum random-selection {
        description
            "Indicates that reconnections should start with
            a random endpoint.";
    }
}
default "first-listed";
description
    "Specifies which of the NETCONF client's endpoints
    the NETCONF server should start with when trying
    to connect to the NETCONF client.";
}
leaf max-attempts {
    type uint8 {
        range "1..max";
    }
    default "3";
    description
        "Specifies the number times the NETCONF server tries
        to connect to a specific endpoint before moving on
        to the next endpoint in the list (round robin).";
}
} // container reconnect-strategy
} // list netconf-client
} // container call-home
} // grouping netconf-server-grouping

// Protocol accessible node, for servers that implement this
// module.

container netconf-server {
    uses netconf-server-grouping;
    description
        "Top-level container for NETCONF server configuration.";
}
```



```
}  
<CODE ENDS>
```

5. Security Considerations

The YANG module defined in this document uses groupings defined in [\[I-D.kwatsen-netconf-tcp-client-server\]](#), [\[I-D.ietf-netconf-ssh-client-server\]](#), and [\[I-D.ietf-netconf-tls-client-server\]](#). Please see the Security Considerations section in those documents for concerns related those groupings.

The YANG modules defined in this document are designed to be accessed via YANG based management protocols, such as NETCONF [\[RFC6241\]](#) and RESTCONF [\[RFC8040\]](#). Both of these protocols have mandatory-to-implement secure transport layers (e.g., SSH, TLS) with mutual authentication.

The NETCONF access control model (NACM) [\[RFC8341\]](#) provides the means to restrict access for particular users to a pre-configured subset of all available protocol operations and content.

There are a number of data nodes defined in the YANG modules that are writable/creatable/deletable (i.e., config true, which is the default). Some of 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:

None of the subtrees or data nodes in the modules defined in this document need to be protected from write operations.

Some of the readable data nodes in the YANG modules 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:

None of the subtrees or data nodes in the modules defined in this document need to be protected from read operations.

Some of the RPC operations in the YANG modules may be considered sensitive or vulnerable in some network environments. It is thus important to control access to these operations. These are the operations and their sensitivity/vulnerability:

The modules defined in this document do not define any 'RPC' or 'action' statements.

6. IANA Considerations

6.1. The IETF XML Registry

This document registers two URIs in the "ns" subregistry of the IETF XML Registry [[RFC3688](#)]. Following the format in [[RFC3688](#)], the following registrations are requested:

URI: urn:ietf:params:xml:ns:yang:ietf-netconf-client
Registrant Contact: The NETCONF WG of the IETF.
XML: N/A, the requested URI is an XML namespace.

URI: urn:ietf:params:xml:ns:yang:ietf-netconf-server
Registrant Contact: The NETCONF WG of the IETF.
XML: N/A, the requested URI is an XML namespace.

6.2. The YANG Module Names Registry

This document registers two YANG modules in the YANG Module Names registry [[RFC6020](#)]. Following the format in [[RFC6020](#)], the the following registrations are requested:

name: ietf-netconf-client
namespace: urn:ietf:params:xml:ns:yang:ietf-netconf-client
prefix: ncc
reference: RFC XXXX

name: ietf-netconf-server
namespace: urn:ietf:params:xml:ns:yang:ietf-netconf-server
prefix: ncs
reference: RFC XXXX

7. References

7.1. Normative References

[I-D.ietf-netconf-keystore]

Watsen, K., "YANG Data Model for a Centralized Keystore Mechanism", [draft-ietf-netconf-keystore-08](#) (work in progress), March 2019.

[I-D.ietf-netconf-ssh-client-server]

Watsen, K., Wu, G., and L. Xia, "YANG Groupings for SSH Clients and SSH Servers", [draft-ietf-netconf-ssh-client-server-12](#) (work in progress), April 2019.

[I-D.ietf-netconf-tls-client-server]

Watsen, K., Wu, G., and L. Xia, "YANG Groupings for TLS Clients and TLS Servers", [draft-ietf-netconf-tls-client-server-11](#) (work in progress), April 2019.

[I-D.kwatsen-netconf-tcp-client-server]

Watsen, K., "YANG Groupings for TCP Clients and TCP Servers", [draft-kwatsen-netconf-tcp-client-server-01](#) (work in progress), April 2019.

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[RFC6020] Bjorklund, M., Ed., "YANG - A Data Modeling Language for the Network Configuration Protocol (NETCONF)", [RFC 6020](#), DOI 10.17487/RFC6020, October 2010, <<https://www.rfc-editor.org/info/rfc6020>>.

[RFC6241] Enns, R., Ed., Bjorklund, M., Ed., Schoenwaelder, J., Ed., and A. Bierman, Ed., "Network Configuration Protocol (NETCONF)", [RFC 6241](#), DOI 10.17487/RFC6241, June 2011, <<https://www.rfc-editor.org/info/rfc6241>>.

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[RFC7407] Bjorklund, M. and J. Schoenwaelder, "A YANG Data Model for SNMP Configuration", [RFC 7407](#), DOI 10.17487/RFC7407, December 2014, <<https://www.rfc-editor.org/info/rfc7407>>.

[RFC7589] Badra, M., Luchuk, A., and J. Schoenwaelder, "Using the NETCONF Protocol over Transport Layer Security (TLS) with Mutual X.509 Authentication", [RFC 7589](#), DOI 10.17487/RFC7589, June 2015, <<https://www.rfc-editor.org/info/rfc7589>>.

[RFC7950] Bjorklund, M., Ed., "The YANG 1.1 Data Modeling Language", [RFC 7950](#), DOI 10.17487/RFC7950, August 2016, <<https://www.rfc-editor.org/info/rfc7950>>.

- [RFC8174] Leiba, B., "Ambiguity of Uppercase vs Lowercase in [RFC 2119](#) Key Words", [BCP 14](#), [RFC 8174](#), DOI 10.17487/RFC8174, May 2017, <<https://www.rfc-editor.org/info/rfc8174>>.

7.2. Informative References

- [I-D.ietf-netconf-trust-anchors]
Watsen, K., "YANG Data Model for Global Trust Anchors", [draft-ietf-netconf-trust-anchors-03](#) (work in progress), March 2019.
- [RFC3688] Mealling, M., "The IETF XML Registry", [BCP 81](#), [RFC 3688](#), DOI 10.17487/RFC3688, January 2004, <<https://www.rfc-editor.org/info/rfc3688>>.
- [RFC8040] Bierman, A., Bjorklund, M., and K. Watsen, "RESTCONF Protocol", [RFC 8040](#), DOI 10.17487/RFC8040, January 2017, <<https://www.rfc-editor.org/info/rfc8040>>.
- [RFC8071] Watsen, K., "NETCONF Call Home and RESTCONF Call Home", [RFC 8071](#), DOI 10.17487/RFC8071, February 2017, <<https://www.rfc-editor.org/info/rfc8071>>.
- [RFC8340] Bjorklund, M. and L. Berger, Ed., "YANG Tree Diagrams", [BCP 215](#), [RFC 8340](#), DOI 10.17487/RFC8340, March 2018, <<https://www.rfc-editor.org/info/rfc8340>>.
- [RFC8341] Bierman, A. and M. Bjorklund, "Network Configuration Access Control Model", STD 91, [RFC 8341](#), DOI 10.17487/RFC8341, March 2018, <<https://www.rfc-editor.org/info/rfc8341>>.

Appendix A. Expanded Tree Diagrams

A.1. Expanded Tree Diagram for 'ietf-netconf-client'

The following tree diagram [RFC8340] provides an overview of the data model for the "ietf-netconf-client" module.

This tree diagram shows all the nodes defined in this module, including those defined by "grouping" statements used by this module.

Please see [Section 3.1](#) for a tree diagram that illustrates what the module looks like without all the "grouping" statements expanded.

===== NOTE: '\\' line wrapping per BCP XX (RFC XXXX) =====

module: ietf-netconf-client

```

+--rw netconf-client
  +--rw initiate! {ssh-initiate or tls-initiate}?
    | +--rw netconf-server* [name]
    |   +--rw name string
    |   +--rw endpoints
    |     | +--rw endpoint* [name]
    |     |   +--rw name string
    |     |   +--rw (transport)
    |     |     +--:(ssh) {ssh-initiate}?
    |     |       +--rw ssh
    |     |         +--rw tcp-client-parameters
    |     |           +--rw remote-address inet:host
    |     |           +--rw remote-port?  inet:port-number
    |     |           +--rw local-address? inet:ip-address
    |     |           +--rw local-port?   inet:port-number
    |     |           +--rw keepalives!
    |     |             +--rw idle-time    uint16
    |     |             +--rw max-probes   uint16
    |     |             +--rw probe-interval uint16
    |     |           +--rw ssh-client-parameters
    |     |             +--rw client-identity
    |     |               +--rw username? string
    |     |               +--rw (auth-type)
    |     |                 +--:(password)
    |     |                   | +--rw password? string
    |     |                   +--:(public-key)
    |     |                     +--rw public-key
    |     |                       +--rw (local-or-keystore)
    |     |                         +--:(local)
    |     |                           {local-keys-sup\
ported}?
    |     |                           +--rw local-definition

```


							+++rw algorithm?
							asymmetric\
-key-algorithm-ref							
							+++rw public-key?
							binary
							+++rw private-key?
							union
							+++x generate-hid\
den-key							
							+---w input
							+---w algori\
thm							
							asym\
metric-key-algorithm-ref							
							+++x install-hidd\
en-key							
							+---w input
							+---w algori\
thm							
							asym\
metric-key-algorithm-ref							
							+---w public\
-key?							
							bina\
ry							
							+---w privat\
e-key?							
							bina\
ry							
							+--:(keystore)
							{keystore-suppo\
rted}??							
							+++rw keystore-refere\
nce?							
							ks:asymmetric\
-key-ref							
							+--:(certificate)
							+++rw certificate
							{sshcmn:ssh-x509-certs\
}?							
							+++rw (local-or-keystore)
							+--:(local)
							{local-keys-sup\
ported}??							
							+++rw local-definition
							+++rw algorithm?
							asymmetric\
-key-algorithm-ref							

						+++rw public-key?
						binary
						+++rw private-key?
						union
						++++x generate-hid\
den-key						
						+---w input
						+---w algori\
thm						
						asym\
metric-key-algorithm-ref						
						++++x install-hidd\
en-key						
						+---w input
						+---w algori\
thm						
						asym\
metric-key-algorithm-ref						
						+---w public\
-key?						
						bina\
ry						
						+---w privat\
e-key?						
						bina\
ry						
						+++rw cert?
						end-entity\
-cert-cms						
						++++n certificate-\
expiration						
						+++ expiration-\
date						
						yang:da\
te-and-time						
						+++:(keystore)
						{keystore-suppo\
rted}?						
						+++rw keystore-refere\
nce?						
						ks:asymmetric\
-key-certificate-ref						
						+++rw server-authentication
						+++rw pinned-ssh-host-keys?
						ta:pinned-host-keys-ref
						{ta:ssh-host-keys}?
						+++rw pinned-ca-certs?
						ta:pinned-certificates-ref


```

| | | {sshcmn:ssh-x509-certs,ta:x5\
09-certificates}?
| | | +--rw pinned-server-certs?
| | | | ta:pinned-certificates-ref
| | | | {sshcmn:ssh-x509-certs,ta:x5\
09-certificates}?
| | | +--rw transport-params
| | | | {ssh-client-transport-params-co\
nfig}?
| | | | +--rw host-key
| | | | | +--rw host-key-alg* identityref
| | | | +--rw key-exchange
| | | | | +--rw key-exchange-alg*
| | | | | | identityref
| | | | +--rw encryption
| | | | | +--rw encryption-alg*
| | | | | | identityref
| | | | +--rw mac
| | | | | +--rw mac-alg* identityref
| | | | +--rw keepalives!
| | | | | {ssh-client-keepalives}?
| | | | +--rw max-wait? uint16
| | | | +--rw max-attempts? uint8
| | | +---:(tls) {tls-initiate}?
| | | | +--rw tls
| | | | | +--rw tcp-client-parameters
| | | | | | +--rw remote-address inet:host
| | | | | | +--rw remote-port? inet:port-number
| | | | | | +--rw local-address? inet:ip-address
| | | | | | +--rw local-port? inet:port-number
| | | | | | +--rw keepalives!
| | | | | | | +--rw idle-time uint16
| | | | | | | +--rw max-probes uint16
| | | | | | | +--rw probe-interval uint16
| | | | | +--rw tls-client-parameters
| | | | | | +--rw client-identity
| | | | | | | +--rw (auth-type)
| | | | | | | | +---:(certificate)
| | | | | | | | | +--rw certificate
| | | | | | | | | | +--rw (local-or-keystore)
| | | | | | | | | | | +---:(local)
| | | | | | | | | | | | {local-keys-sup\
ported}?
| | | | | | | | | | | | +--rw local-definition
| | | | | | | | | | | | +--rw algorithm?
| | | | | | | | | | | | | asymmetric\
-key-algorithm-ref
| | | | | | | | | | | | +--rw public-key?

```


						binary
						+++rw private-key?
						union
						++++x generate-hid\
den-key						
						++++w input
						++++w algori\
thm						
						asym\
metric-key-algorithm-ref						
						++++x install-hidd\
en-key						
						++++w input
						++++w algori\
thm						
						asym\
metric-key-algorithm-ref						
						++++w public\
-key?						
						bina\
ry						
						++++w privat\
e-key?						
						bina\
ry						
						+++rw cert?
						end-entity\
-cert-cms						
						++++n certificate-\
expiration						
						+-- expiration-\
date						
						yang:da\
te-and-time						
						+-: (keystore)
						{keystore-suppo\
rted}}?						
						+++rw keystore-refere\
nce?						
						ks:asymmetric\
-key-certificate-ref						
						+++rw server-authentication
						+++rw pinned-ca-certs?
						ta:pinned-certificates-ref
						{ta:x509-certificates}?
						+++rw pinned-server-certs?
						ta:pinned-certificates-ref
						{ta:x509-certificates}?

[illegible]


```

}?
```

					+-rw local-definition
					+-rw algorithm?
lgorithm-ref					asymmetric-key-a\
					+-rw public-key?
					binary
					+-rw private-key?
					union
					+-x generate-hidden-key
					+-w input
					+-w algorithm
-key-algorithm-ref					asymmetric\
					+-x install-hidden-key
					+-w input
					+-w algorithm
-key-algorithm-ref					asymmetric\
					+-w public-key?
					binary
					+-w private-key?
					binary
					+-:(keystore)
					{keystore-supported}?
					+-rw keystore-reference?
ef					ks:asymmetric-key-r\
					+-:(certificate)
					+-rw certificate
					{sshcmn:ssh-x509-certs}?
					+-rw (local-or-keystore)
					+-:(local)
					{local-keys-supported\
}?					
					+-rw local-definition
					+-rw algorithm?
lgorithm-ref					asymmetric-key-a\
					+-rw public-key?
					binary
					+-rw private-key?
					union
					+-x generate-hidden-key
					+-w input
					+-w algorithm
-key-algorithm-ref					asymmetric\


```

|         |         |         +---x install-hidden-key
|         |         |         | +---w input
|         |         |         | +---w algorithm
|         |         |         | |         asymmetric\
-key-algorithm-ref
|         |         |         | +---w public-key?
|         |         |         | |         binary
|         |         |         | +---w private-key?
|         |         |         | |         binary
|         |         |         +--rw cert?
|         |         |         |         end-entity-cert-\
cms
|         |         |         +---n certificate-expira\
tion
|         |         |         +-- expiration-date
|         |         |         |         yang:date-and\
-time
|         |         |         +--:(keystore)
|         |         |         |         {keystore-supported}?
|         |         |         +--rw keystore-reference?
|         |         |         |         ks:asymmetric-key-c\
ertificate-ref
|         +--rw server-authentication
|         | +--rw pinned-ssh-host-keys?
|         | |         ta:pinned-host-keys-ref
|         | |         {ta:ssh-host-keys}?
|         | +--rw pinned-ca-certs?
|         | |         ta:pinned-certificates-ref
|         | |         {sshcmn:ssh-x509-certs,ta:x509-cer\
tificates}?
|         | +--rw pinned-server-certs?
|         | |         ta:pinned-certificates-ref
|         | |         {sshcmn:ssh-x509-certs,ta:x509-cer\
tificates}?
|         +--rw transport-params
|         |         {ssh-client-transport-params-config}?
|         | +--rw host-key
|         | | +--rw host-key-alg*   identityref
|         | +--rw key-exchange
|         | | +--rw key-exchange-alg*   identityref
|         | +--rw encryption
|         | | +--rw encryption-alg*   identityref
|         | +--rw mac
|         | | +--rw mac-alg*   identityref
|         +--rw keepalives! {ssh-client-keepalives}?
|         +--rw max-wait?      uint16
|         +--rw max-attempts?  uint8
+--:(tls) {tls-listen}?

```



```

+--rw tls
  +--rw tcp-server-parameters
    | +--rw local-address      inet:ip-address
    | +--rw local-port?       inet:port-number
    | +--rw keepalives!
    |   +--rw idle-time        uint16
    |   +--rw max-probes       uint16
    |   +--rw probe-interval   uint16
  +--rw tls-client-parameters
    +--rw client-identity
      | +--rw (auth-type)
      |   +--:(certificate)
      |     +--rw certificate
      |       +--rw (local-or-keystore)
      |         +--:(local)
      |           | {local-keys-supported\
}?:
      |           | +--rw local-definition
      |           | +--rw algorithm?
      |           |   | asymmetric-key-a\
algorithm-ref
      |           |   |
      |           |   | +--rw public-key?
      |           |   |   | binary
      |           |   | +--rw private-key?
      |           |   |   | union
      |           |   | +---x generate-hidden-key
      |           |   |   | +---w input
      |           |   |   | +---w algorithm
      |           |   |   | asymmetric\
-key-algorithm-ref
      |           |   |   | +---x install-hidden-key
      |           |   |   |   | +---w input
      |           |   |   |   | +---w algorithm
      |           |   |   |   | asymmetric\
-key-algorithm-ref
      |           |   |   |   | +---w public-key?
      |           |   |   |   |   | binary
      |           |   |   |   | +---w private-key?
      |           |   |   |   |   | binary
      |           |   |   | +--rw cert?
      |           |   |   |   | end-entity-cert-\
cms
      |           |   |   | +---n certificate-expira\
tion
      |           |   |   | +-- expiration-date
      |           |   |   |   | yang:date-and\
-time
      |           |   |   | +--:(keystore)

```



```

|                                     {keystore-supported}?
|                                     +--rw keystore-reference?
|                                     ks:asymmetric-key-c\
ertificate-ref
+--rw server-authentication
| +--rw pinned-ca-certs?
| |   ta:pinned-certificates-ref
| |   {ta:x509-certificates}?
| +--rw pinned-server-certs?
|   ta:pinned-certificates-ref
|   {ta:x509-certificates}?
+--rw hello-params
|   {tls-client-hello-params-config}?
| +--rw tls-versions
| | +--rw tls-version*   identityref
| +--rw cipher-suites
|   +--rw cipher-suite*  identityref
+--rw keepalives! {tls-client-keepalives}?
    +--rw max-wait?      uint16
    +--rw max-attempts?  uint8

```

A.2. Expanded Tree Diagram for 'ietf-netconf-server'

The following tree diagram [RFC8340] provides an overview of the data model for the "ietf-netconf-server" module.

This tree diagram shows all the nodes defined in this module, including those defined by "grouping" statements used by this module.

Please see [Section 4.1](#) for a tree diagram that illustrates what the module looks like without all the "grouping" statements expanded.

===== NOTE: '\ ' line wrapping per BCP XX (RFC XXXX) =====

```

module: ietf-netconf-server
+--rw netconf-server
| +--rw listen! {ssh-listen or tls-listen}?
| | +--rw idle-timeout?  uint16
| | +--rw endpoint* [name]
| |   +--rw name        string
| |   +--rw (transport)
| |     +--:(ssh) {ssh-listen}?
| |       | +--rw ssh
| |       |   +--rw tcp-server-parameters
| |       |     +--rw local-address    inet:ip-address
| |       |     +--rw local-port?     inet:port-number
| |       |     +--rw keepalives!
| |       |       +--rw idle-time      uint16

```


			+--rw max-probes	uint16
			+--rw probe-interval	uint16
		+--rw ssh-server-parameters		
		+--rw server-identity		
		+--rw host-key* [name]		
		+--rw name		string
		+--rw (host-key-type)		
		+--:(public-key)		
		+--rw public-key		
		+--rw (local-or-keystore)		
		+--:(local)		
				{local-keys-supported}?}
			+--rw local-definition	
			+--rw algorithm?	
				asymmetric-key-algorithm-ref
			+--rw public-key?	
				binary
			+--rw private-key?	
				union
			+---x generate-hidden-key	
				+---w input
				+---w algorithm
				asymmetric-key-algorithm-ref
			+---x install-hidden-key	
				+---w input
				+---w algorithm
				asymmetric-key-algorithm-ref
			+---w public-key?	
				binary
			+---w private-key?	
				binary
			+--:(keystore)	
				{keystore-supported}?}
			+--rw keystore-reference?	
				ks:asymmetric-key-algorithm-ref
			+--:(certificate)	
			+--rw certificate	
				{sshcmn:ssh-x509-certs}?

				+++rw (local-or-keystore)
				+++:(local)
				{local-keys-suppor\
ted}?				
				+--rw local-definition
				+--rw algorithm?
				asymmetric-ke\
y-algorithm-ref				
				+--rw public-key?
				binary
				+--rw private-key?
				union
				+---x generate-hidden\
-key				
				+---w input
				+---w algorithm
				asymmet\
ric-key-algorithm-ref				
				+---x install-hidden-\
key				
				+---w input
				+---w algorithm
				asymmet\
ric-key-algorithm-ref				
				+---w public-ke\
y?				
				binary
				+---w private-k\
ey?				
				binary
				+--rw cert?
				end-entity-ce\
rt-cms				
				+---n certificate-exp\
iration				
				+-- expiration-date
				yang:date-\
and-time				
				+++:(keystore)
				{keystore-supporte\
d}?				
				+--rw keystore-reference?
				ks:asymmetric-ke\
y-certificate-ref				
				+--rw client-authentication
				+--rw supported-authentication-methods
				+--rw publickey? empty
				+--rw passsword? empty


```

|         |         |         |         | +--rw hostbased?    empty
|         |         |         |         | +--rw none?        empty
|         |         |         |         | +--rw other*       string
|         |         |         | +--rw (local-or-external)
|         |         |         |     +--:(local)
|         |         |         |         | {local-client-auth-supported}?
|         |         |         |         | +--rw users
|         |         |         |         |     +--rw user* [name]
|         |         |         |         |         +--rw name          string
|         |         |         |         |         +--rw password?
|         |         |         |         |         |     ianach:crypt-hash
|         |         |         |         |         +--rw authorized-key* [name]
|         |         |         |         |             +--rw name          string
|         |         |         |         |             +--rw algorithm    string
|         |         |         |         |             +--rw key-data     binary
|         |         |         |     +--:(external)
|         |         |         |         {external-client-auth-supporte\
d}?
|         |         |         |         +--rw client-auth-defined-elsewhere?
|         |         |         |         empty
|         |         | +--rw transport-params
|         |         |     {ssh-server-transport-params-config}?
|         |         | +--rw host-key
|         |         |     | +--rw host-key-alg*    identityref
|         |         |     +--rw key-exchange
|         |         |     | +--rw key-exchange-alg* identityref
|         |         |     +--rw encryption
|         |         |     | +--rw encryption-alg*  identityref
|         |         |     +--rw mac
|         |         |     | +--rw mac-alg*         identityref
|         |         | +--rw keepalives! {ssh-server-keepalives}?
|         |         |     +--rw max-wait?          uint16
|         |         |     +--rw max-attempts?      uint8
|         |         | +--:(tls) {tls-listen}?
|         |         |     +--rw tls
|         |         |         +--rw tcp-server-parameters
|         |         |         | +--rw local-address    inet:ip-address
|         |         |         | +--rw local-port?      inet:port-number
|         |         |         | +--rw keepalives!
|         |         |         |     +--rw idle-time      uint16
|         |         |         |     +--rw max-probes     uint16
|         |         |         |     +--rw probe-interval uint16
|         |         | +--rw tls-server-parameters
|         |         |     +--rw server-identity
|         |         |         +--rw (local-or-keystore)
|         |         |         | +--:(local) {local-keys-supported}?
|         |         |         |     | +--rw local-definition
|         |         |         |     | +--rw algorithm?

```



```

ref      |      |      |      |      asymmetric-key-algorithm-\
          |      |      |      |      +--rw public-key?
          |      |      |      |      |      binary
          |      |      |      |      +--rw private-key?
          |      |      |      |      |      union
          |      |      |      |      +---x generate-hidden-key
          |      |      |      |      |      +---w input
          |      |      |      |      |      +---w algorithm
          |      |      |      |      |      asymmetric-key-algo\
rithm-ref      |      |      |      |      +---x install-hidden-key
          |      |      |      |      |      +---w input
          |      |      |      |      |      +---w algorithm
          |      |      |      |      |      |      asymmetric-key-algo\
rithm-ref      |      |      |      |      |      +---w public-key?      binary
          |      |      |      |      |      +---w private-key?      binary
          |      |      |      |      |      +--rw cert?
          |      |      |      |      |      |      end-entity-cert-cms
          |      |      |      |      |      +---n certificate-expiration
          |      |      |      |      |      |      +-- expiration-date
          |      |      |      |      |      |      yang:date-and-time
          |      |      |      |      |      +---:(keystore) {keystore-supported}?
          |      |      |      |      |      +--rw keystore-reference?
          |      |      |      |      |      ks:asymmetric-key-certificat\
e-ref      |      |      |      |      +--rw client-authentication!
          |      |      |      |      |      +--rw (required-or-optional)
          |      |      |      |      |      |      +---:(required)
          |      |      |      |      |      |      |      +--rw required?
          |      |      |      |      |      |      |      |      empty
          |      |      |      |      |      |      |      +---:(optional)
          |      |      |      |      |      |      |      +--rw optional?
          |      |      |      |      |      |      |      |      empty
          |      |      |      |      |      |      +--rw (local-or-external)
          |      |      |      |      |      |      |      +---:(local)
          |      |      |      |      |      |      |      |      {local-client-auth-supported}?
          |      |      |      |      |      |      |      +--rw pinned-ca-certs?
          |      |      |      |      |      |      |      |      ta:pinned-certificates-ref
          |      |      |      |      |      |      |      |      {ta:x509-certificates}?
          |      |      |      |      |      |      |      +--rw pinned-client-certs?
          |      |      |      |      |      |      |      |      ta:pinned-certificates-ref
          |      |      |      |      |      |      |      |      {ta:x509-certificates}?
          |      |      |      |      |      |      |      +---:(external)
          |      |      |      |      |      |      |      |      {external-client-auth-supporte\
d}?      |      |      |      |      |      +--rw client-auth-defined-elsewhere?

```



```

| | | empty
| | | +--rw cert-maps
| | | | +--rw cert-to-name* [id]
| | | | | +--rw id uint32
| | | | | +--rw fingerprint
| | | | | | x509c2n:tls-fingerprint
| | | | | +--rw map-type identityref
| | | | | +--rw name string
| | | +--rw hello-params
| | | | {tls-server-hello-params-config}?
| | | +--rw tls-versions
| | | | +--rw tls-version* identityref
| | | +--rw cipher-suites
| | | | +--rw cipher-suite* identityref
| | | +--rw keepalives! {tls-server-keepalives}?
| | | | +--rw max-wait? uint16
| | | | +--rw max-attempts? uint8
+--rw call-home! {ssh-call-home or tls-call-home}?
  +--rw netconf-client* [name]
    +--rw name string
    +--rw endpoints
      +--rw endpoint* [name]
        +--rw name string
        +--rw (transport)
          +--:(ssh) {ssh-call-home}?
            +--rw ssh
              +--rw tcp-client-parameters
                +--rw remote-address inet:host
                +--rw remote-port? inet:port-number
                +--rw local-address? inet:ip-address
                +--rw local-port? inet:port-number
                +--rw keepalives!
                  +--rw idle-time uint16
                  +--rw max-probes uint16
                  +--rw probe-interval uint16
              +--rw ssh-server-parameters
                +--rw server-identity
                  +--rw host-key* [name]
                    +--rw name string
                    +--rw (host-key-type)
                      +--:(public-key)
                        +--rw public-key
                          +--rw (local-or-keystore)
                            +--:(local)
                              {local-keys-\
supported}?
| | | | | | | +--rw local-defini\
tion

```


						+++rw algorithm?
						asymmet\
ric-key-algorithm-ref						
						+++rw public-ke\
y?						
						binary
						+++rw private-k\
ey?						
						union
						+++x generate-\
hidden-key						
						+---w input
						+---w alg\
orithm						
						a\
symmetric-key-algorithm-ref						
						+++x install-h\
idden-key						
						+---w input
						+---w alg\
orithm						
						a\
symmetric-key-algorithm-ref						
						+---w pub\
lic-key?						
						b\
inary						
						+---w pri\
vate-key?						
						b\
inary						
					+++:(keystore)	
					{keystore-su\	
pported}?						
					+++rw keystore-ref\	
erence?						
					ks:asymmet\	
ric-key-ref						
				+++:(certificate)		
				+++rw certificate		
				{sshcmn:ssh-x509-ce\		
rts}?						
				+++rw (local-or-keystore)		
				+++:(local)		
				{local-keys-\		
supported}?						
					+++rw local-defini\	
tion						

					+++rw algorithm?
					asymmet\
ric-key-algorithm-ref					
					+++rw public-ke\
y?					
					binary
					+++rw private-k\
ey?					
					union
					----x generate-\
hidden-key					
					+---w input
					+---w alg\
orithm					
					a\
symmetric-key-algorithm-ref					
					----x install-h\
idden-key					
					+---w input
					+---w alg\
orithm					
					a\
symmetric-key-algorithm-ref					
					+---w pub\
lic-key?					
					b\
inary					
					+---w pri\
vate-key?					
					b\
inary					
					+++rw cert?
					end-ent\
ity-cert-cms					
					----n certifica\
te-expiration					
					+++ expirati\
on-date					
					yang\
:date-and-time					
					+++:(keystore)
					{keystore-su\
pported}?}					
					+++rw keystore-ref\
erence?					
					ks:asymmet\
ric-key-certificate-ref					
					+++rw client-authentication


```

ds      |      |      | +--rw supported-authentication-metho\
      |      |      | | +--rw publickey?    empty
      |      |      | | +--rw password?    empty
      |      |      | | +--rw hostbased?    empty
      |      |      | | +--rw none?         empty
      |      |      | | +--rw other*        string
      |      |      | +--rw (local-or-external)
      |      |      |   +--:(local)
      |      |      |     {local-client-auth-suppo\
rted}}? |      |      |       +--rw users
      |      |      |       | +--rw user* [name]
      |      |      |       |   +--rw name
      |      |      |       |   | string
      |      |      |       |   +--rw password?
      |      |      |       |   |   ianach:crypt-hash
      |      |      |       |   +--rw authorized-key*
      |      |      |       |   | [name]
      |      |      |       |   +--rw name
      |      |      |       |   | string
      |      |      |       |   +--rw algorithm
      |      |      |       |   | string
      |      |      |       |   +--rw key-data
      |      |      |       |   | binary
      |      |      |       +--:(external)
      |      |      |         {external-client-auth-su\
pported}}? |      |      |       +--rw client-auth-defined-else\
where?    |      |      |         empty
      |      |      | +--rw transport-params
      |      |      |   {ssh-server-transport-params-co\
nfig}}?  |      |      | +--rw host-key
      |      |      | | +--rw host-key-alg*  identityref
      |      |      | +--rw key-exchange
      |      |      | | +--rw key-exchange-alg*
      |      |      | |   identityref
      |      |      | +--rw encryption
      |      |      | | +--rw encryption-alg*
      |      |      | |   identityref
      |      |      | +--rw mac
      |      |      | | +--rw mac-alg*      identityref
      |      |      | +--rw keepalives!
      |      |      |   {ssh-server-keepalives}?
      |      |      | +--rw max-wait?      uint16
      |      |      | +--rw max-attempts?   uint8

```



```

|         +---:(tls) {tls-call-home}?
|         +---rw tls
|             +---rw tcp-client-parameters
|                 | +---rw remote-address      inet:host
|                 | +---rw remote-port?       inet:port-number
|                 | +---rw local-address?     inet:ip-address
|                 | +---rw local-port?       inet:port-number
|                 | +---rw keepalives!
|                 |     +---rw idle-time      uint16
|                 |     +---rw max-probes     uint16
|                 |     +---rw probe-interval uint16
|             +---rw tls-server-parameters
|                 +---rw server-identity
|                     | +---rw (local-or-keystore)
|                     |     +---:(local)
|                     |         | {local-keys-supported}?
|                     |         | +---rw local-definition
|                     |         |     +---rw algorithm?
|                     |         |         | asymmetric-key-algo\
rithm-ref |         |         | +---rw public-key?
|         |         |         |     | binary
|         |         |         | +---rw private-key?
|         |         |         |     | union
|         |         |         | +---x generate-hidden-key
|         |         |         |     | +---w input
|         |         |         |     | +---w algorithm
|         |         |         |         | asymmetric-ke\
y-algorithm-ref |         |         | +---x install-hidden-key
|         |         |         |     | +---w input
|         |         |         |     | +---w algorithm
|         |         |         |         | asymmetric-ke\
y-algorithm-ref |         |         | +---w public-key?
|         |         |         |     | | binary
|         |         |         |     | +---w private-key?
|         |         |         |         | binary
|         |         |         | +---rw cert?
|         |         |         |     | end-entity-cert-cms
|         |         |         | +---n certificate-expiration
|         |         |         |     | +--- expiration-date
|         |         |         |         | yang:date-and-ti\
me |         |         |         |
|         |         |         | +---:(keystore)
|         |         |         |     {keystore-supported}?
|         |         |         | +---rw keystore-reference?
|         |         |         |         ks:asymmetric-key-cert\

```



```

ificate-ref
|
|         +--rw client-authentication!
|         |   +--rw (required-or-optional)
|         |   |   +--:(required)
|         |   |   |   +--rw required?
|         |   |   |   |   empty
|         |   |   |   +--:(optional)
|         |   |   |   +--rw optional?
|         |   |   |   |   empty
|         |   +--rw (local-or-external)
|         |   |   +--:(local)
|         |   |   |   {local-client-auth-suppo\
rted}?
|         |   |   |   +--rw pinned-ca-certs?
|         |   |   |   |   ta:pinned-certificates\
-ref
|         |   |   |   |   {ta:x509-certificates}?
|         |   |   |   +--rw pinned-client-certs?
|         |   |   |   |   ta:pinned-certificates\
-ref
|         |   |   |   |   {ta:x509-certificates}?
|         |   |   |   +--:(external)
|         |   |   |   {external-client-auth-su\
pported}?
|         |   +--rw client-auth-defined-else\
where?
|         |   |   empty
|         |   +--rw cert-maps
|         |   |   +--rw cert-to-name* [id]
|         |   |   |   +--rw id                uint32
|         |   |   |   +--rw fingerprint
|         |   |   |   |   x509c2n:tls-fingerprint
|         |   |   |   +--rw map-type
|         |   |   |   |   identityref
|         |   |   |   +--rw name                string
|         |   +--rw hello-params
|         |   |   {tls-server-hello-params-config\
}?
|         |   |   +--rw tls-versions
|         |   |   |   +--rw tls-version*    identityref
|         |   |   +--rw cipher-suites
|         |   |   |   +--rw cipher-suite*    identityref
|         |   +--rw keepalives!
|         |   |   {tls-server-keepalives}?
|         |   |   +--rw max-wait?            uint16
|         |   |   +--rw max-attempts?        uint8
+--rw connection-type
|   +--rw (connection-type)

```



```
|      +--:(persistent-connection)
|      |  +--rw persistent!
|      +--:(periodic-connection)
|      |  +--rw periodic!
|      |      +--rw period?          uint16
|      |      +--rw anchor-time?     yang:date-and-time
|      |      +--rw idle-timeout?    uint16
+--rw reconnect-strategy
    +--rw start-with?      enumeration
    +--rw max-attempts?    uint8
```

[Appendix B.](#) Change Log

[B.1.](#) 00 to 01

- o Renamed "keychain" to "keystore".

[B.2.](#) 01 to 02

- o Added to ietf-netconf-client ability to connected to a cluster of endpoints, including a reconnection-strategy.
- o Added to ietf-netconf-client the ability to configure connection-type and also keep-alive strategy.
- o Updated both modules to accommodate new groupings in the ssh/tls drafts.

[B.3.](#) 02 to 03

- o Refined use of tls-client-grouping to add a must statement indicating that the TLS client must specify a client-certificate.
- o Changed 'netconf-client' to be a grouping (not a container).

[B.4.](#) 03 to 04

- o Added [RFC 8174](#) to Requirements Language Section.
- o Replaced refine statement in ietf-netconf-client to add a mandatory true.
- o Added refine statement in ietf-netconf-server to add a must statement.
- o Now there are containers and groupings, for both the client and server models.

B.5. 04 to 05

- o Now tree diagrams reference ietf-netmod-yang-tree-diagrams
- o Updated examples to inline key and certificates (no longer a leafref to keystore)

B.6. 05 to 06

- o Fixed change log missing section issue.
- o Updated examples to match latest updates to the crypto-types, trust-anchors, and keystore drafts.
- o Reduced line length of the YANG modules to fit within 69 columns.

B.7. 06 to 07

- o Removed "idle-timeout" from "persistent" connection config.
- o Added "random-selection" for reconnection-strategy's "starts-with" enum.
- o Replaced "connection-type" choice default (persistent) with "mandatory true".
- o Reduced the periodic-connection's "idle-timeout" from 5 to 2 minutes.
- o Replaced reconnect-timeout with period/anchor-time combo.

B.8. 07 to 08

- o Modified examples to be compatible with new crypto-types algs

B.9. 08 to 09

- o Corrected use of "mandatory true" for "address" leafs.
- o Updated examples to reflect update to groupings defined in the keystore draft.
- o Updated to use groupings defined in new TCP and HTTP drafts.
- o Updated copyright date, boilerplate template, affiliation, and folding algorithm.

[B.10.](#) 09 to 10

- o Reformatted YANG modules.

[B.11.](#) 10 to 11

- o Adjusted for the top-level "demux container" added to groupings imported from other modules.
- o Added "must" expressions to ensure that keepalives are not configured for "periodic" connections.
- o Updated the boilerplate text in module-level "description" statement to match copyeditor convention.
- o Moved "expanded" tree diagrams to the Appendix.

[B.12.](#) 11 to 12

- o Removed the "Design Considerations" section.
- o Removed the 'must' statement limiting keepalives in periodic connections.
- o Updated models and examples to reflect removal of the "demux" containers in the imported models.
- o Updated the "periodic-connection" description statements to be more like the RESTCONF draft, especially where it described dropping the underlying TCP connection.
- o Updated text to better reference where certain examples come from (e.g., which Section in which draft).
- o In the server model, commented out the "must 'pinned-ca-certs or pinned-client-certs'" statement to reflect change made in the TLS draft whereby the trust anchors MAY be defined externally.
- o Replaced the 'listen', 'initiate', and 'call-home' features with boolean expressions.

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