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:

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

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

- "XXXX" --> the assigned RFC value for this draft
- "AAAA" --> the assigned RFC value for I-D.ietf-netconf-tcp-client-server
- "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 "2019-07-02" --> 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].
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 not 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.
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].
<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>rsa2048</algorithm>
                    <private-key>base64encodedvalue==</private-key>
                  </local-definition>
                </public-key>
              </client-identity>
              <server-authentication>
                <ca-certs>explicitly-trusted-server-ca-certs</ca-certs>
                <server-certs>explicitly-trusted-server-certs</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>
          <ssh>
            </ssh>
        </endpoint>
      </endpoints>
    </netconf-server>
  </initiate>
</netconf-client>
<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>rsa2048</algorithm>
        <private-key>base64encodedvalue==</private-key>
        <public-key>base64encodedvalue==</public-key>
      </local-definition>
    </public-key>
  </client-identity>
  <server-authentication>
    <ca-certs>explicitly-trusted-server-ca-certs</ca-certs>
    <server-certs>explicitly-trusted-server-certs</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>
    <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>rsa2048</algorithm>
        <private-key>base64encodedvalue==</private-key>
        <public-key>base64encodedvalue==</public-key>
      </local-definition>
    </public-key>
  </client-identity>
  <server-authentication>
    <ca-certs>explicitly-trusted-server-ca-certs</ca-certs>
    <server-certs>explicitly-trusted-server-certs</server-certs>
    <ssh-host-keys>explicitly-trusted-ssh-host-keys</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@2019-07-02.yang"
module ietf-netconf-client {
  yang-version 1.1;
  prefix ncc;

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

  import ietf-tcp-client {
    prefix tcpc;
    reference
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 2019-07-02; // stable grouping definitions
  reference
    "RFC BBBB: YANG Groupings for SSH Clients and SSH Servers";
}

import ietf-tls-client {
  prefix tlsc;
  revision-date 2019-07-02; // stable grouping definitions
  reference
    "RFC CCCC: YANG Groupings for TLS Clients and TLS Servers";
}

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

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.";
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 2019-07-02 {
  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;
        description
        "Selects between available transports.";
        case ssh {
          if-feature "ssh-initiate";
        }
      }
    }
  }
}

// Groupings
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 "8300";
                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 specified.";
                }
            }
        }
    }
}
container tls-client-parameters {
  must "client-identity" {
    description
    "NETCONF/TLS clients MUST pass some authentication credentials.";
  }
  description
  "A wrapper around the TLS client parameters to avoid name collisions.";
  uses tlsc:tls-client-grouping;
}
}
} // 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. 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).";
    }
}
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;
}
}

container 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 {
      must "client-identity" {
        description
        "NETCONF/TLS clients MUST pass some authentication credentials."
      }
      description
      "A wrapper around the TLS client parameters to avoid name collisions."
      uses tlsc:tls-client-grouping;
    }
  }
}
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.
++:(ssh) {ssh-listen}?
  ++ ssh
    ++ tcp-server-parameters
      | ++--- u tcps:tcp-server-grouping
      ++ ssh-server-parameters
        ++--- u sshs:ssh-server-grouping
    ++:(tls) {tls-listen}?
      ++ tls
        ++ tcp-server-parameters
          | ++--- u tcps:tcp-server-grouping
          ++ tls-server-parameters
            ++--- u tlss:tls-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 tcpc:tcp-client-grouping
                        ++ ssh-server-parameters
                          ++--- u sshs:ssh-server-grouping
                    ++:(tls) {tls-call-home}?
                      ++ tls
                        ++ tcp-client-parameters
                          | ++--- u tcpc:tcp-client-grouping
                          ++ tls-server-parameters
                            ++--- u tlss:tls-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: '\n' line wrapping per BCP XX (RFC XXXX) ===========

```xml
<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>rsa2048</algorithm>
                  <private-key>base64encodedvalue==</private-key>
                  <public-key>base64encodedvalue==</public-key>
                </local-definition>
              </public-key>
            </host-key>
            <client-authentication>
              <supported-authentication-methods>
                <public-key/>
              </supported-authentication-methods>
              <client-auth-defined-elsewhere/>
            </client-authentication>
          </server-identity>
        </ssh-server-parameters>
      </ssh>
    </endpoint>
    <endpoint> <!-- listening for TLS sessions -->
      <name>netconf/tls</name>
      <x509c2n>
        <local-definition>
          <algorithm>rsa2048</algorithm>
          <private-key>base64encodedvalue==</private-key>
          <public-key>base64encodedvalue==</public-key>
        </local-definition>
      </x509c2n>
      <x509c2n>
        <local-definition>
          <algorithm>rsa2048</algorithm>
          <private-key>base64encodedvalue==</private-key>
          <public-key>base64encodedvalue==</public-key>
        </local-definition>
      </x509c2n>
      <x509c2n>
        <local-definition>
          <algorithm>rsa2048</algorithm>
          <private-key>base64encodedvalue==</private-key>
          <public-key>base64encodedvalue==</public-key>
        </local-definition>
      </x509c2n>
      <x509c2n>
        <local-definition>
          <algorithm>rsa2048</algorithm>
          <private-key>base64encodedvalue==</private-key>
          <public-key>base64encodedvalue==</public-key>
        </local-definition>
      </x509c2n>
      <x509c2n>
        <local-definition>
          <algorithm>rsa2048</algorithm>
          <private-key>base64encodedvalue==</private-key>
          <public-key>base64encodedvalue==</public-key>
        </local-definition>
      </x509c2n>
      <x509c2n>
        <local-definition>
          <algorithm>rsa2048</algorithm>
          <private-key>base64encodedvalue==</private-key>
          <public-key>base64encodedvalue==</public-key>
        </local-definition>
      </x509c2n>
    </endpoint>
  </listen>
</netconf-server>
```
<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>rsa2048</algorithm>
        <private-key>base64encodedvalue==</private-key>
        <public-key>base64encodedvalue==</public-key>
        <cert>base64encodedvalue==</cert>
      </local-definition>
      <server-identity>
      </client-authentication>
      <required/>
      <ca-certs>explicitly-trusted-client-ca-certs</ca-certs>
      <client-certs>explicitly-trusted-client-certs</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>
    <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>
  </netconf-client>
  <endpoints>
    <endpoint>
      <name>east-data-center</name>
      <ssh>
        <tcp-client-parameters>
          <remote-address>east.config-mgr.example.com</remote-address>
        </tcp-client-parameters>
      </ssh>
    </endpoint>
  </endpoints>
</call-home>
<tcp-client-parameters>
</tcp-client-parameters>
<ssh-server-parameters>
<server-identity>
<host-key>
<name>deployment-specific-certificate</name>
<public-key>
<local-definition>
<algorithm>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-authentication>
</ssh-server-parameters>
</ssh>
</endpoint>
<name>west-data-center</name>
<ssh>
<tcp-client-parameters>
<remote-address>west.config-mgr.example.com</remote-address>
</tcp-client-parameters>
<ssh-server-parameters>
<server-identity>
<host-key>
<name>deployment-specific-certificate</name>
<public-key>
<local-definition>
<algorithm>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-authentication>
</ssh-server-parameters>
</ssh>
</endpoint>
<client-auth-defined-elsewhere/>
</client-authentication>
</ssh-server-parameters>
</ssh>
</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>
</netconf-client>

<tcp-client-parameters>
<remote-address>east.analytics.example.com</remote-address>
<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>rsa2048</algorithm>
<private-key>base64encodedvalue==</private-key>
<public-key>base64encodedvalue==</public-key>
<cert>base64encodedvalue==</cert>
</local-definition>
</server-identity>
</tcp-client-parameters>
<client-authentication>
(required/>
<ca-certs>explicitly-trusted-client-ca-certs</ca-certs>
<client-certs>explicitly-trusted-client-certs</client-certs>
</client-authentication>
<cert-maps>

Watsen
Expires January 3, 2020
<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-address>
      <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>rsa2048</algorithm>
          <private-key>base64encodedvalue==</private-key>
          <public-key>base64encodedvalue==</public-key>
          <cert>base64encodedvalue==</cert>
        </local-definition>
      </server-identity>
      <client-authentication>
        <required/>
        <ca-certs>explicitly-trusted-client-ca-certs</ca-certs>
        <client-certs>explicitly-trusted-client-certs</client-certs>
      </client-authentication>
      <cert-maps>
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@2019-07-02.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;
  }

  <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>

  <client-authentication>
    <keepalives>
      <max-wait>30</max-wait>
      <max-attempts>3</max-attempts>
    </keepalives>
  </client-authentication>

  <tls-server-parameters>
    <max-wait>30</max-wait>
    <max-attempts>3</max-attempts>
  </tls-server-parameters>

  <endpoints>
    <endpoint>
      <connection-type>
        <persistent/>
      </connection-type>
      <reconnect-strategy>
        <start-with>first-listed</start-with>
        <max-attempts>3</max-attempts>
      </reconnect-strategy>
    </endpoint>
  </endpoints>
}</netconf-client>
</call-home>
</netconf-server>
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 2019-07-02; // stable grouping definitions
    reference
        "RFC BBBB: YANG Groupings for SSH Clients and SSH Servers";
}

import ietf-tls-server {
    prefix tlss;
    revision-date 2019-07-02; // stable grouping definitions
    reference
        "RFC CCCC: YANG Groupings for TLS Clients and TLS Servers";
}

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

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

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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.


revision 2019-07-02 {
  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

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.";
    }
  }
}

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 ‘ca-certs or 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 WWWW: 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 'ca-certs or 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 WWWW: 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."

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 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 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
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:
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 following registrations are requested:

name:         ietf-netconf-client
prefix:       ncc
reference:    RFC XXXX

name:         ietf-netconf-server
prefix:       ncs
reference:    RFC XXXX

7. References

7.1. Normative References

[I-D.ietf-netconf-keystore]

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

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

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


7.2. Informative References

[I-D.ietf-netconf-trust-anchors]


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) ===========
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|     |        |        |     |        |        {local-definition}?
|     |        |        |     |        |  +--rw local-definition
|     |        |        |     |        |    +--rw algorithm
|     |        |        |     |        |     asymmetric\n
|     |        |        |     |        |  \-key-algorithm-t
|     |        |        |     |        |     +--rw public-key
|     |        |        |     |        |     binary
|     |        |        |     |        |    +--rw (private-key)\n
|     |        |        |     |        |     \-type)\n|     |        |        |     |        |    +--:(private-key)\n
|     |        |        |     |        |     \y
|     |        |        |     |        |    +--rw privat\n
|     |        |        |     |        |     \e-key?\n|     |        |        |     |        |    bina\n
|     |        |        |     |        |     \ry
|     |        |        |     |        |    +--:(hidden-pri\n
|     |        |        |     |        |     \vate-key)\n|     |        |        |     |        |    +--rw hidden\n
|     |        |        |     |        |     \-private-key?\n|     |        |        |     |        |    empty
|     |        |        |     |        |    +--:(encrypted-\n
|     |        |        |     |        |     \private-key)\n|     |        |        |     |        |    +--rw encryp\n
|     |        |        |     |        |     \ted-private-key\n|     |        |        |     |        |    +--rw (ke\n
|     |        |        |     |        |     \y-type)\n|     |        |        |     |        |    +--:(s\n
|     |        |        |     |        |     \symmetric-key-ref)\n|     |        |        |     |        |    +--:leafref
|     |        |        |     |        |     \ (keystore-supported)?\n|     |        |        |     |        |    \ symm\racric-key-ref?  leafref
|     |        |        |     |        |     \ (keystore-supported)\

|     |        |        |     |        |     \ asymmetric-key-ref?  leafref
|     |        |        |     |        |     \ (keystore-supported)\
|     |        |        |     |        |    b\n
|     |        |        |     |        |     \inary\n|     |        |        |     |        |    +--:(keystore)\n
|     |        |        |     |        |     \rted)?\n|     |        |        |     |        |    +--rw keystore-refere\n
|     |        |        |     |        |     \nce?\n
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\-key-ref
  +--:(certificate)
    +--rw certificate
      {sshcmn:ssh-x509-certs}
\)?
  +--rw (local-or-keystore)
    +--:(local)
      {local-definition}
\-key-supported)?
  +--rw local-definition
    +--rw algorithm
      asymmetric\n\-key-algorithm-t
  +--rw public-key
    binary
  +--rw (private-key)\n\-type)
  +--:(private-key)\n\y)
  +--rw private\n\e-key? 
  +-- bina\n\ry
  +--:(hidden-private\n\vate-key)
  +--rw hidden\n\-private-key? 
  empty
  +--:(encrypted-private-key)\n\private-key) 
  +--rw encrypted-private-key
\ted-private-key 
  +--rw (key-type)\n\y-type) 
  +--:(symmetric-key-ref)\n\y \-symmetric-key-ref? leafref
    \ (keystore-supported)? \(symmetric-key-ref) 
    +--:(a)\n\y \-symmetric-key-ref? leafref
    \ (keystore-supported)?\n    +--rw (val)
| | | | | | \ue?
| | | | | +--rw cert?
| | | | +--rw cert?
| | | +--n certificate-
| | | +-- expiration-
| | | yang:da
| | +--x generate-cer
| | +--w input
| | +--w subject
| | bina
| | +--w attrib
| | bina
| | +--ro output
| +--ro certificate
| | bina
| | +--rw keystore-refere
| | {keystore-supported}
| +--rw asymmetric-k
| | ks:asymmetric
| | +--rw certificate?
| | +--rw ssh-host-keys?
| | ts:host-keys-ref
| | {ts:ssh-host-keys}?
| | +--rw ca-certs?
| | ts:certificates-ref
| | {sshcmn:ssh-x509-certificates,ts:x5}
| \09-certificates)?
| | +--rw server-certs?
| | ts:certificates-ref
\09-certificates)?
\n---rw transport-params
   (ssh-client-transport-params-config)
   \n---rw transport-params
   (ssh-client-transport-params-cofig)
   \n---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
      (local-binding-supported)?
   +--rw local-port? inet:port-number
      (local-binding-supported)?
---rw keepalives!
   (keepalives-supported)?
---rw idle-time uint16
---rw max-probes uint16
---rw probe-interval uint16
---rw tls-client-parameters
---rw client-identity
   +--rw (local-or-keystore)
      +--:(local)
      |   {local-definitions-supported}
---rw local-definition
   +--rw algorithm
      |   asymmetric-key-algorithm
---rw public-key
   |   binary
   +--rw (private-key-type)
      +--:(private-key)
      |   +--rw private-key?
---rw server-authentication
  +--rw ca-certs?
    |    ts:certificates-ref
    |    {ts:x509-certificates}?
  +--rw server-certs?
    ts:certificates-ref
    {ts:x509-certificates}?
---rw hello-params
    {tls-client-hello-params-config}\n}\n
  +--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
---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
---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! (keepalives-supported)?
            |            +--rw idle-time uint16
            +--rw max-probes uint16
            +--rw probe-interval uint16
        +--rw ssh-client-parameters
          +--rw client-identity
            +--rw username? string
\-time
\te-signing-request
    +---x generate-certificat\n        +---w input
            +---w subject
                binary
            +---w attributes?
                binary
        +---ro output
            +---ro certificate-
\signing-request
    binary
    +--:(keystore)
        +---w keystore-reference
            +---w asymmetric-key?
                ks:asymmetric-key\n\y-ref
    +---w certificate?
\leafref
    +--rw server-authentication
        +--rw ssh-host-keys? ts:host-keys-ref
            |  +---w ca-certs? ts:certificates-ref
            |      sshcmn:ssh-x509-certs,ts:x509-cer\n\tificates}\?
        +--rw server-certs? ts:certificates-ref
            sshcmn:ssh-x509-certs,ts:x509-cer\n\tificates}\?
    +--rw transport-params
        +--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! (keepalives-supported)?
| +--rw idle-time            uint16 |
| +--rw max-probes          uint16 |
| +--rw probe-interval      uint16 |
| +--rw tls-client-parameters |
| +--rw client-identity     |
|     +--rw (local-or-keystore) |
|     |     +--:(local) |
|     |     |     {local-definitions-supported}? |
|     |     |     +--rw local-definition |
|     |     |     +--rw algorithm |
|     |     |     |     asymmetric-key-algorithm-t |
|     |     |     +--rw public-key |
|     |     |     |     binary |
|     |     |     +--rw (private-key-type) |
|     |     |     |     +--:(private-key) |
|     |     |     |     |     +--rw private-key? |
|     |     |     |     |     |     binary |
|     |     |     |     |     +--:(hidden-private-key) |
|     |     |     |     |     |     +--rw hidden-private-key? |
|     |     |     |     |     |     |     empty |
|     |     |     |     |     +--:(encrypted-private-key) |
|     |     |     |     +--rw encrypted-private-key |
|     |     |     |     |     |     +--rw (key-type) |
|     |     |     |     |     |     |     +--:(symmetric-key-ref) |
| {\f}

{leafref} |
| | | | | | +--rw symmetric-key |

\y-ref?{leafref} |
| | | | | | +--:(asymmetric-key-ref) |

\supported)? |
| | | | | +--rw asymmetric-key |

\ey-ref?{leafref} |
| | | | | | +--rw asymmetric-key |

\supported)? |
| | | | | +--rw value? |
| | | | | | binary |
| +--rw cert? |
| | | end-entity-cert-cms |
| +--n certificate-expiration |
| | +-- expiration-date |
| | | yang:date-and-time |
| +--x generate-certificate-signin\g-request |
| +--w input |
| | +--w subject binary |
| | +--w attributes? binary |
| +--ro output
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) ===========
++rw keepalives! {keepalives-supported}?
  ++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)
      ++rw public-key
        ++rw (local-or-keystore)
          ++:(local)

\-supported)?

++rw local-definition
  ++rw algorithm
    asymmetric-key-algorithm
++rw public-key
  binary
++rw (private-key-ty\
\y-algorithm-t
\pe)
\ey?
\e-key)
\ivate-key?  
\vate-key)
\-private-key
++rw (key-t\
\type)
\metric-key-ref)
\symmetric-key-ref? leafref
\(keystore-supported)?
\metric-key-ref)
\asymmetric-key-ref? leafref
\ {keystore-supported}?
  \ry
  \d)?
  \y-ref
\-supported)?
\y-algorithm-t
\pe
\ey?
\e-key
\ivate-key?
\vate-key)
\-private-key
\ype
\etric-key-ref
\ymmetric-key-ref?
  leafref
\ {keystore-supported}?


(metric-key-ref)
| | | | +--rw 
/asymmetric-key-ref? leafref
| | | \ {keystore-supported}?
| | | +--rw value?
| | \ry
| | | +--rw cert?
\rt-cms
| | | +--n certificate-exp\ration
| | | +-- expiration-date yang:date-time
\rand-time
| | | +--x generate-certificate-request
| | | +-- input
| | | | +-- subject binary
| | | | +-- attribute binary
| | | | +-- output binary
| | | +-- certificate-signing-request
| | | +-- (keystore)
| | \d)?
| | | +--rw keystore-reference
| | | +--rw asymmetric-key? ks:asymmetric
\key-ref
| | | +--rw certificate? 
\ leafref

---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? ianchor:crypto-hash
   +--rw authorized-key* [name]
      +--rw name string
      +--rw algorithm string
      +--rw key-data binary
+-:(external)
   {external-client-auth-support}
   +--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! {keepalives-supported}?
            +--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-definitions-supported}?
                  +--rw local-definition
                     +--rw algorithm
                        | asymmetric-key-algorithm-t
                        | binary
                     +--rw public-key
                        | +:(private-key)
                        |   +--rw private-key?
++-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-definition)?
++-rw local-definition?
++-rw algorithm
  ++-rw asymmetric-key-algorithm-t
    ++-rw public-key
      ++-rw (private-key)
        ++-:(local)
          (local-definition)?
++-rw secret-key
  ++-:(binary)
++-rw private-key
    ++-:(hidden-private-key)
      ++-:(encrypted-private-key)
        ++-:(symmetric-key-ref)
          ++-:(symmetric-key-ref)? leafref
            (keystore-supported)?
              ++-:

\erence
\c-key?
\metric-key-ref
\te? leafref
\ds
\rted)?
\pported)?
\where?
\nfig)?
---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 inet:host
        ++--rw remote-port? inet:port-number
        ++--rw local-address? inet:ip-address
            | (local-binding-supported)?
        ++--rw local-port? inet:port-number
            | (local-binding-supported)?
        ++--rw keepalives!
            {keepalives-supported}?
            ++--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-definitions-supported}?
    ++--rw local-definition
        ++--rw algorithm
            asymetric-key-algo
        ++--rw public-key
            binary
            ++--rw (private-key-type)
                +--:(private-key)
                    ++--rw private-key?
                        binary
                    ++--:(hidden-private-key)
                        ++--rw hidden-private-
        ++--:(hidden-private-key)
            ++--rw encrypted-private-
        ++--:(encrypted-private-k)
++--rw key?
| | | | | empty
++--:(symmetric-
\key-ref)
|           | | | | | +--rw symmetric
\ric-key-ref? leafref
|           | | | | | (key)
\store-supported)?
|           | | | | | +--:(asymmetric)
\-key-ref)
|           | | | | | +--rw asymmetric
\tric-key-ref? leafref
|           | | | | | (key)
\store-supported)?
|           | | | | | +--rw value?
|           | | | | |     binary
|           | | | | |     +--rw cert?
|           | | | | |     end-entity-cert-cms
|           | | | | |     +--n certificate-expiration
|           | | | | |     +-- expiration-date
|           | | | | |    .yang:date-and-time
\me
|           | | | | | +--x generate-certificate-
\signing-request
|           | | | | | +--w input
|           | | | | |     +--w subject
|           | | | | |     binary
|           | | | | |     +--w attributes?
|           | | | | |     binary
|           | | | | |     +--ro output
|           | | | | |     +--ro certificate-signing-request
\ning-request
|           | | | | |     binary
|           | | | | |     +--:(keystore)
|           | | | | |     {keystore-supported}?
|           | | | | |     +--rw keystore-reference
|           | | | | |     +--rw asymmetric-key?
|           | | | | | | ks:asymmetric-key-ref
\ef
|           | | | | | +--rw certificate? leaf
\fref
|           | | | | | +--rw client-authentication!
|           | | | | |     +--:(required-or-optional)
|           | | | | |     +--:(required)
|           | | | | |     | +--rw required?
|           | | | | |     |     empty
|           | | | | |     +--:(optional)
|           | | | | |     | +--rw optional?
|           | | | | |     |     empty
|           | | | | |     +--rw (local-or-external)
|           | | | | |     +--:(local)
\rted)?
| | | | {local-client-auth-supported}
++-rw ca-certs?
| | | ts:certificates-ref
| | {ts:x509-certificates}?
++-rw client-certs?
| | ts:certificates-ref
| {ts:x509-certificates}?
++:(external)
| {external-client-auth-supported}
\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)
| | | | ++-rw persistent!
| | | | ++-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

- Renamed "keychain" to "keystore".

B.2. 01 to 02

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

B.3. 02 to 03

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

B.4. 03 to 04

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

B.5. 04 to 05

- Now tree diagrams reference ietf-netmod-yang-tree-diagrams
- Updated examples to inline key and certificates (no longer a leafref to keystore)
B.6. 05 to 06

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

B.7. 06 to 07

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

B.8. 07 to 08

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

B.9. 08 to 09

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

B.10. 09 to 10

- Reformatted YANG modules.
B.11. 10 to 11

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

B.12. 11 to 12

- Removed the "Design Considerations" section.
- Removed the 'must' statement limiting keepalives in periodic connections.
- Updated models and examples to reflect removal of the "demux" containers in the imported models.
- Updated the "periodic-connection" description statements to be more like the RESTCONF draft, especially where it described dropping the underlying TCP connection.
- Updated text to better reference where certain examples come from (e.g., which Section in which draft).
- 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.
- Replaced the 'listen', 'initiate', and 'call-home' features with boolean expressions.

B.13. 12 to 13

- Updated to reflect changes in trust-anchors drafts (e.g., s/trust-anchors/truststore/g + s/pinned.//)

B.14. 13 to 14

- Adjusting from change in TLS client model (removing the top-level 'certificate' container), by swapping refining-in a 'mandatory true' statement with a 'must' statement outside the 'uses' statement.
Updated examples to reflect ietf-crypto-types change (e.g., identities --> enumerations)

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