NETCONF Client and Server Models
draft-ietf-netconf-netconf-client-server-04

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-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
- "YYYY" --> the assigned RFC value for I-D.ietf-netconf-ssh-client-server
- "ZZZZ" --> the assigned RFC value for I-D.ietf-netconf-tls-client-server
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1. Introduction

This document defines two YANG [RFC7950] 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.

NETCONF is defined by [RFC6241]. SSH is defined by [RFC4252], [RFC4253], and [RFC4254]. TLS is defined by [RFC5246]. NETCONF Call Home is defined by [RFC8071]).

1.1. 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.

1.2. Tree Diagrams

A simplified graphical representation of the data models is used in this document. The meaning of the symbols in these diagrams is as follows:

- Brackets "[" and "]" enclose list keys.
- Braces "{" and "}" enclose feature names, and indicate that the
named feature must be present for the subtree to be present.

- Abbreviations before data node names: "rw" means configuration (read-write) and "ro" state data (read-only).
- Symbols after data node names: "?" means an optional node, "!" means a presence container, and "*" denotes a list and leaf-list.
- Parentheses enclose choice and case nodes, and case nodes are also marked with a colon (":").
- Ellipsis ("...") stands for contents of subtrees that are not shown.

2. 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.

This model supports both the SSH and TLS transport protocols, using the SSH client and TLS client groupings defined in [I-D.ietf-netconf-ssh-client-server] and [I-D.ietf-netconf-tls-client-server] respectively.

All private keys and trusted certificates are held in the keystore model defined in [I-D.ietf-netconf-keystore].

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

2.1. Tree Diagram

Just the container is displayed below, but there is also a grouping that the container is using.

Note: all lines are folded at column 71 with no '\' character.

module: ietf-netconf-client
  +--rw netconf-client
    +--rw initiate {initiate}?
      | +--rw netconf-server* [name]
+++rw name string
+++rw (transport)
  +++:(ssh) {ssh-initiate}?
    +++rw ssh
      +++rw endpoints
        +++rw endpoint* [name]
          +++rw name string
          +++rw address inet:host
          +++rw port? inet:port-number
        +++rw server-auth
          +++rw trusted-ssh-host-keys?
            -> /ks:keystore/trusted-host-keys/name
          +++rw trusted-ca-certs? leafref
            {sshcom:ssh-x509-certs}?
          +++rw trusted-server-certs? leafref
            {sshcom:ssh-x509-certs}?
        +++rw client-auth
          +++rw username? string
        +++rw (auth-type)
          +++:(certificate)
            +++rw certificate? leafref
            {sshcom:ssh-x509-certs}?
          +++:(public-key)
            +++rw public-key?
            -> /ks:keystore/keys/key/name
          +++:(password)
        +++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 compression
              +++rw compression-alg* identityref
          +++:(tls) {tls-initiate}?
        +++rw tls
++-rw address? inet:ip-address
++-rw port? inet:port-number
++-rw server-auth
  | +++-rw trusted-ssh-host-keys?
  |     |   -> /ks:keystore/trusted-host-keys/name
  |   ++-rw trusted-ca-certs? leafref
  |     |   {sshcom:ssh-x509-certs}?
  |   ++-rw trusted-server-certs? leafref
  |     |   {sshcom:ssh-x509-certs}?
++-rw client-auth
  | +++-rw username? string
  |   +++-rw (auth-type)
  |     |     +++-:(certificate)
  |     |     |   +++-rw certificate? leafref
  |     |     |     |   {sshcom:ssh-x509-certs}?
  |     |     |     +++-:(public-key)
  |     |     |     |   +++-rw public-key?
  |     |     |     |     |   -> /ks:keystore/keys/key/name
  |     |     |     |     +++-:(password)
  |     |     |     +++-rw password? string
++-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 compression
  |     |     |     |     |     |     +++-rw compression-alg* identityref
  |     |     +++-:(tls) {tls-listen}?
++-rw tls
  |   +++-rw address? inet:ip-address
  |   +++-rw port? inet:port-number
++-rw server-auth
  |   +++-rw trusted-ca-certs? leafref
  |   +++-rw trusted-server-certs? leafref
++-rw client-auth

2.2. 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 2.2 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>
      <ssh>
         <endpoints>
            <endpoint>
               <name>corp-fw1.example.com</name>
               <address>corp-fw1.example.com</address>
            </endpoint>
            <endpoint>
               <name>corp-fw2.example.com</name>
               <address>corp-fw2.example.com</address>
            </endpoint>
         </endpoints>
         <server-auth>
            <trusted-server-certs>deployment-specific-ca-certs</trusted-server-certs>
         </server-auth>
         <client-auth>
            <username>foobar</username>
            <public-key>ex-rsa-key</public-key>
         </client-auth>
      </ssh>
   </netconf-server>

<!-- endpoints to listen for NETCONF Call Home connections on -->
<listen>
   <endpoint>
      <name>Intranet-facing listener</name>
      <ssh>
         <address>11.22.33.44</address>
         <server-auth>
            <trusted-ca-certs>deployment-specific-ca-certs</trusted-ca-certs>
         </server-auth>
         <client-auth>
            <username>foobar</username>
            <public-key>ex-rsa-key</public-key>
         </client-auth>
      </ssh>
   </endpoint>
</listen>
</initiate>
</netconf-client>
2.3. YANG Model

This YANG module imports YANG types from [RFC6991] and [RFC7407].

<CODE BEGINS> file "ietf-netconf-client@2017-07-03.yang"

module ietf-netconf-client {
    yang-version 1.1;

    prefix "ncc";

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

    import ietf-ssh-client {
        prefix ss;
        revision-date 2017-06-13; // stable grouping definitions
        reference
            "RFC YYYY: SSH Client and Server Models";
    }

    import ietf-tls-client {
        prefix ts;
        revision-date 2017-06-13; // stable grouping definitions
        reference
            "RFC ZZZZ: TLS Client and Server Models";
    }

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

    contact
        "WG Web:  <http://tools.ietf.org/wg/netconf/>
        WG List:  <mailto:netconf@ietf.org>"
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; see the RFC itself for full legal notices.

revision "2017-07-03" {
    description
        "Initial version";
    reference
        "RFC XXXX: NETCONF Client and Server Models";
}

// Features

feature initiate {
    description
        "The 'initiate' feature indicates that the NETCONF client supports initiating NETCONF connections to NETCONF servers using at least one transport (e.g., SSH, TLS, etc.).";
}
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 listen {
    description
    "The 'listen' feature indicates that the NETCONF client supports opening a port to accept NETCONF server call home connections using at least one transport (e.g., SSH, TLS, etc.).";
}

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
container netconf-client {
  uses netconf-client;
  description
    "Top-level container for NETCONF client configuration."
}

grouping netconf-client {
  description
    "Top-level grouping for NETCONF client configuration."
}

container initiate {
  if-feature initiate;
  description
    "Configures client initiating underlying TCP connections."
  list netconf-server {
    key name;
    description
      "List of NETCONF servers the NETCONF client is to initiate
      connections to."
    leaf name {
      type string;
      description
        "An arbitrary name for the NETCONF server."
    }
  }
  choice transport {
    mandatory true;
    description
      "Selects between available transports."
  }
  case ssh {
    if-feature ssh-initiate;
    container ssh {
      description
        "Specifies SSH-specific transport configuration."
      uses endpoints-container {
        refine endpoints/endpoint/port {
          default 830;
        }
      }
    }
  }
}
uses ss:ssh-client-grouping;
} // end ssh

case tls {
  if-feature tls-initiate;
  container tls {
    description
    "Specifies TLS-specific transport configuration.";
    uses endpoints-container {
      refine endpoints/endpoint/port {
        default 6513;
      }
    }
  }
  uses ts:tls-client-grouping {
    refine "client-auth/auth-type" {
      mandatory true;
      description
      "NETCONF/TLS clients MUST pass some authentication credentials.";
    }
  }
}
} // end tls
} // end transport

container connection-type {
  description
  "Indicates the kind of connection to use.";
  choice connection-type {
    description
    "Selects between available connection types.";
    case persistent-connection {
      container persistent {
        presence true;
        description
        "Maintain a persistent connection to the NETCONF server. If the connection goes down, immediately start trying to reconnect to it, using the";  
    }
  }
} // end connection-type
reconnection strategy.

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

leaf idle-timeout {
  type uint32;
  units "seconds";
  default 86400;  // one day;
  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 client will never drop a session because it is idle. Sessions that have a notification subscription active are never dropped.";
}

container keep-alives {
  description
  "Configures the keep-alive policy, to proactively test the aliveness of the SSH/TLS server. An unresponsive SSH/TLS server will be dropped after approximately max-attempts * max-wait seconds.";
  reference
  "RFC 8071: NETCONF Call Home and RESTCONF Call Home, Section 3.1, item S6";
  leaf max-wait {
    type uint16 {
      range "1..max";
    }
    units seconds;
    default 30;
    description
    "Sets the amount of time in seconds after which if no data has been received from the SSH/TLS server, a SSH/TLS-level message will be sent to test the aliveness of the SSH/TLS server.";
  }
  leaf max-attempts {
type uint8;
default 3;
description
"Sets the maximum number of sequential keep-alive
messages that can fail to obtain a response from
the SSH/TLS server before assuming the SSH/TLS
server is no longer alive.";
}
}
}
case periodic-connection {
  container periodic {
    presence true;
    description
    "Periodically connect to the NETCONF server, so that
    the NETCONF server may deliver messages pending for
    the NETCONF client. The NETCONF server must close
    the connection when it is ready to release it. Once
    the connection has been closed, the NETCONF client
    will restart its timer until the next connection."
  leaf idle-timeout {
    type uint16;
    units "seconds";
    default 300; // five 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. Sessions that
    have a notification subscription active are
    never dropped.";
  }
  leaf reconnect-timeout {
    type uint16 {
      range "1..max";
    }
    units minutes;
    default 60;
    description
    "Sets the maximum amount of unconnected time the
    NETCONF client will wait before re-establishing
    the connection."
  }
}
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a connection to the NETCONF server. The NETCONF client may initiate a connection before this time if desired (e.g., to set configuration)."

} } }
}

} 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.";

}

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).";

} // end netconf-server
} // end initiate

container listen {
if-feature listen;
description
"Configures client accepting call-home TCP connections.";

leaf max-sessions {
  type uint16;
default 0;
description
"Specifies the maximum number of concurrent sessions that can be active at one time. The value 0 indicates that no artificial session limit should be used."
}

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;
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."
      leaf address {
        type inet:ip-address;
        description
          "The IP address to listen for call-home connections."
      }
      leaf port {
        type inet:port-number;
        default 4334;
        description
          "The port number to listen for call-home connections."
      }
      uses ss:ssh-client-grouping;
    }
  }
  case tls {
    if-feature tls-listen;
    container tls {
      description
        "TLS-specific listening configuration for inbound
        connections."
      leaf address {
        type inet:ip-address;
        description
          "The IP address to listen for call-home connections."
      }
      leaf port {
        type inet:port-number;
        default 4335;
        description
          "The port number to listen for call-home connections."
      }
    }
  }
}
"The port number to listen for call-home connections."
}
uses ts:tls-client-grouping {
  refine "client-auth/auth-type" {
    mandatory true;
    description
    "NETCONF/TLS clients MUST pass some authentication credentials.";
  }
}
}
}
} // end transport
} // end endpoint
} // end listen


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} // end netconf-client

grouping endpoints-container {
  description
  "This grouping is used to configure a set of NETCONF servers
   a NETCONF client may initiate connections to."
  container endpoints {
    description
    "Container for the list of endpoints."
    list endpoint {
      key name;
      unique "address port";
      min-elements 1;
      ordered-by user;
      description
      "A non-empty user-ordered list of endpoints for this NETCONF
       client to try to connect to. Defining more than one enables
       high-availability.";
      leaf name {
        type string;
        description
        "An arbitrary name for this endpoint."
      } leaf address {
        type inet:host;
3. The NETCONF Server Model

The NETCONF server model presented in this section supports servers both listening for connections as well as initiating call-home connections.

This model supports both the SSH and TLS transport protocols, using the SSH server and TLS server groupings defined in [I-D.ietf-netconf-ssh-client-server] and [I-D.ietf-netconf-tls-client-server] respectively.

All private keys and trusted certificates are held in the keystore model defined in [I-D.ietf-netconf-keystore].

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

3.1. Tree Diagram
Just the container is displayed below, but there is also a grouping that the container is using.

Note: all lines are folded at column 71 with no '\' character.

```
module: ietf-netconf-server
  +--rw netconf-server
    |  +--rw session-options
    |     |  +--rw hello-timeout?  uint16
    |     |  +--rw listen {listen}?
    |     |     +--rw max-sessions?  uint16
    |     |     +--rw idle-timeout?  uint16
    |     +--rw endpoint* [name]
    |        |  +--rw name  string
    |        +--rw (transport)
    |            +--:(ssh) {ssh-listen}?
    |            |  +--rw ssh
    |            |     |  +--rw address?  inet:ip-address
    |            |     |  +--rw port?  inet:port-number
    |            |            +--rw host-keys
    |            |            |  +--rw host-key* [name]
    |            |            |     |  +--rw name  string
    |            |            |     +--rw (host-key-type)
    |            |            |     |     +--rw public-key?
    |            |            |     |     |     +--rw certificate?  leafref
    |            |            |     |     |        {sshcom:ssh-x509-certs}?
    |            |            |     |     +--rw client-cert-auth {sshcom:ssh-x509-certs}?
    |            |            |     |     |  +--rw trusted-ca-certs?  leafref
    |            |            |     |     |  +--rw trusted-client-certs?  leafref
    |            |            +--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 public-key?
   -> /ks:keystore/keys/key/name
---:(certificate)
   ---rw certificate? leafref
      {sshcom:ssh-x509-certs}?
---rw client-cert-auth {sshcom:ssh-x509-certs}?
   ---rw trusted-ca-certs? leafref
   ---rw trusted-client-certs? leafref
---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 compression
      | ---rw compression-alg* identityref
---:(tls) {tls-call-home}?
   ---rw tls
   ---rw endpoints
      | ---rw endpoint* [name]
      |   ---rw name string
      |   ---rw address inet:host
      |   ---rw port? inet:port-number
   ---rw certificates
      | ---rw certificate* [name]
      |   ---rw name leafref
   ---rw client-auth
      | ---rw trusted-ca-certs? leafref
      | ---rw trusted-client-certs? leafref
   ---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
3.2. 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 2.2 of [I-D.ietf-netconf-keystore].

```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">

 <!-- listening for SSH and TLS connections -->
 <listen>
   <endpoint> <!-- listening for SSH connections -->
     <name>netconf/ssh</name>
     <ssh>
       <address>11.22.33.44</address>
       <host-keys>
         <host-key>
           <name>public-key</name>
           <public-key>ex-rsa-key</public-key>
         </host-key>
         <host-key>
           <name>certificate</name>
           <certificate>builtin-idevid-cert</certificate>
         </host-key>
       </host-keys>
     </ssh>
   </endpoint>
 </listen>
</netconf-server>
```
<client-cert-auth>
  <trusted-ca-certs>deployment-specific-ca-certs</trusted-ca-certs>
  <trusted-client-certs>explicitly-trusted-client-certs</trusted-client-certs>
</client-cert-auth>
</ssh>
</endpoint>
@endpoint> <!-- listening for TLS sessions -->
<name>netconf/tls</name>
<tls>
  <address>11.22.33.44</address>
  <certificates>
    <certificate>
      <name>tls-ec-cert</name>
    </certificate>
  </certificates>
  <client-auth>
    <trusted-ca-certs>deployment-specific-ca-certs</trusted-ca-certs>
    <trusted-client-certs>explicitly-trusted-client-certs</trusted-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-auth>
</tls>
</endpoint>
</listen>

<!-- calling home to an SSH and TLS based NETCONF clients -->
<call-home>
  <netconf-client> <!-- SSH-based client -->
    <name>config-mgr</name>
    <ssh>
      <endpoints>
<endpoint>
  <name>east-data-center</name>
  <address>11.22.33.44</address>
</endpoint>
<endpoint>
  <name>west-data-center</name>
</endpoint>

<host-keys>
  <host-key>
    <name>certificate</name>
    <certificate>builtin-idevid-cert</certificate>
  </host-key>
</host-keys>
<client-cert-auth>
  <trusted-ca-certs>deployment-specific-ca-certs</trusted-ca-certs>
  <trusted-client-certs>explicitly-trusted-client-certs</trusted-client-certs>
</client-cert-auth>
</ssh>
<connection-type>
  <periodic>
    <idle-timeout>300</idle-timeout>
    <reconnect-timeout>60</reconnect-timeout>
  </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>event-correlator</name>
  <tls>
    <endpoints>
      <endpoint>
        <name>east-data-center</name>
        <address>22.33.44.55</address>
      </endpoint>
      <endpoint>
        <name>west-data-center</name>
      </endpoint>
    </endpoints>
  </tls>
</netconf-client>
<address>33.44.55.66</address>
</endpoint>
</endpoints>
<certificates>
  <certificate>
    <name>tls-ec-cert</name>
  </certificate>
</certificates>
<client-auth>
  <trusted-ca-certs>deployment-specific-ca-certs</trusted-ca-certs>
  <trusted-client-certs>explicitly-trusted-client-certs</trusted-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-auth>
</tls>
<connection-type>
  <persistent>
    <idle-timeout>300</idle-timeout>
    <keep-alives>
      <max-wait>30</max-wait>
      <max-attempts>3</max-attempts>
    </keep-alives>
  </persistent>
</connection-type>
<reconnect-strategy>
  <start-with>first-listed</start-with>
  <max-attempts>3</max-attempts>
</reconnect-strategy>
</netconf-client>
</call-home>
3.3. YANG Model

This YANG module imports YANG types from [RFC6991] and [RFC7407].

<CODE BEGINS> file "ietf-netconf-server@2017-07-03.yang"

module ietf-netconf-server {
  yang-version 1.1;

  namespace "urn:ietf:params:xml:ns:yang:ietf-netconf-server";
  prefix "ncs";

  import ietf-inet-types {
    prefix inet;
    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-ssh-server {
    prefix ss;
    revision-date 2017-06-13; // stable grouping definitions
    reference
      "RFC YYYY: SSH Client and Server Models";
  }

  import ietf-tls-server {
    prefix ts;
    revision-date 2017-06-13; // stable grouping definitions
    reference
      "RFC ZZZZ: TLS Client and Server Models";
  }

  organization
The 'listen' feature indicates that the NETCONF server supports opening a port to accept NETCONF client connections.
using at least one transport (e.g., SSH, TLS, etc.).

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 call-home {
    description
    "The 'call-home' feature indicates that the NETCONF server supports initiating NETCONF call home connections to NETCONF clients using at least one transport (e.g., SSH, TLS, etc.)."
    reference
    "RFC 8071: NETCONF Call Home and RESTCONF Call Home"
}

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"
}

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

grouping netconf-server {
    description
    "Top-level grouping for NETCONF server configuration."
}

container session-options { // SHOULD WE REMOVE THIS ALTOGETHER?
    description
    "NETCONF session options, independent of transport or connection strategy."
    leaf hello-timeout {
        type uint16;
        units "seconds";
        default 600;
        description
        "Specifies the maximum number of seconds that a SSH/TLS connection may wait for a hello message to be received. A connection will be dropped if no hello message is received before this number of seconds elapses. If set to zero, then the server will wait forever for a hello message."
    }
}

container listen {
    if-feature listen;
    description
    "Configures listen behavior";
}
leaf max-sessions {
    type uint16;
    default 0;
    description
    "Specifies the maximum number of concurrent sessions
    that can be active at one time. The value 0 indicates
    that no artificial session limit should be used."
}
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;
    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."
            leaf address {
                type inet:ip-address;
                description
                "The IP address of the interface to listen on. The
                SSH server will listen on all interfaces if no value
                is specified. Please note that some addresses have
                special meanings (e.g., '0.0.0.0' and '::').";
            }
        }
    }
}
leaf port {
  type inet:port-number;
  default 830;
  description "The local port number on this interface the SSH server listens on."
}

uses ss:ssh-server-grouping;

}

case tls {
  if-feature tls-listen;
  container tls {
    description "TLS-specific listening configuration for inbound connections."
    leaf address {
      type inet:ip-address;
      description "The IP address of the interface to listen on. The TLS server will listen on all interfaces if no value is specified. Please note that some addresses have special meanings (e.g., '0.0.0.0' and '::').";
    }
    leaf port {
      type inet:port-number;
      default 6513;
      description "The local port number on this interface the TLS server listens on."
    }
    uses ts:tls-server-grouping {
      refine "client-auth" {
        must 'trusted-ca-certs or trusted-client-certs';
        description "NETCONF/TLS servers MUST validate client certificates.";
      }
      augment "client-auth" {
        description "Augments in the cert-to-name structure.";
        uses cert-maps-grouping;
      }
    }
  }
}
container call-home {
    if-feature call-home;
    description
        "Configures call-home behavior";
    list netconf-client {
        key name;
        description
            "List of NETCONF clients the NETCONF server is to initiate
            call-home connections to.";
        leaf name {
            type string;
            description
                "An arbitrary name for the remote NETCONF client.";
        }
        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.";
                    uses endpoints-container {
                        refine endpoints/endpoint/port {
                            default 4334;
                        }
                    }
                    uses ss:ssh-server-grouping;
                }
            }
        }
    }
}

if-feature tls-call-home;
container tls {
    description
    "Specifies TLS-specific call-home transport configuration."
    uses endpoints-container {
        refine endpoints/endpoint/port {
            default 4335;
        }
    }
    uses ts:tls-server-grouping {
        refine "client-auth" {
            must 'trusted-ca-certs or trusted-client-certs';
            description
            "NETCONF/TLS servers MUST validate client certificates.";
        }
        augment "client-auth" {
            description
            "Augments in the cert-to-name structure.";
            uses cert-maps-grouping;
        }
    }
}
container connection-type {
    description
    "Indicates the kind of connection to use.";
    choice connection-type {
        description
        "Selects between available connection types.";
        case persistent-connection {
            container persistent {
                presence true;
                description
                "Maintain a persistent connection to the NETCONF client. If the connection goes down, immediately start trying to reconnect to it, 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.

```
leaf idle-timeout {
  type uint32;
  units "seconds";
  default 86400; // one day;
  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."
}
```

```
container keep-alives {
  description
    "Configures the keep-alive policy, to proactively test the aliveness of the SSH/TLS client. An unresponsive SSH/TLS client will be dropped after approximately max-attempts * max-wait seconds."
  reference
    "RFC 8071: NETCONF Call Home and RESTCONF Call Home, Section 3.1, item S6"

  leaf max-wait {
    type uint16 {
      range "1..max"
    }
    units seconds;
    default 30;
    description
      "Sets the amount of time in seconds after which if no data has been received from the SSH/TLS client, a SSH/TLS-level message will be sent to test the aliveness of the SSH/TLS client."
  }

  leaf max-attempts {
    type uint8;
    default 3;
  }
```
description
"Sets the maximum number of sequential keep-alive
messages that can fail to obtain a response from
the SSH/TLS client before assuming the SSH/TLS
client is no longer alive."
}
}
}
case periodic-connection {
  container periodic {
    presence true;
    description
    "Periodically connect to the NETCONF client, so that
the NETCONF client may deliver messages pending for
the NETCONF server. The NETCONF client must close
the connection when it is ready to release it. Once
the connection has been closed, the NETCONF server
will restart its timer until the next connection."
    leaf idle-timeout {
      type uint16;
      units "seconds";
      default 300; // five minutes
      description
      "Specifies the maximum number of seconds that a
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."
    }
    leaf reconnect-timeout {
      type uint16 {
        range "1..max";
      }
      units minutes;
      default 60;
      description
      "Sets the maximum amount of unconnected time the

NETCONF server will wait before re-establishing a connection to the NETCONF client. The NETCONF server may initiate a connection before this time if desired (e.g., to deliver an event notification message).

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.";
      }
    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).";
}

grouping cert-maps-grouping {
  description
  "A grouping that defines a container around the
cert-to-name structure defined in RFC 7407.";
  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";
  }
}

grouping endpoints-container {
  description
  "This grouping is used to configure a set of NETCONF clients
  a NETCONF server may initiate call-home connections to."
}

container endpoints {
description
  "Container for the list of endpoints.";
list endpoint {
  key name;
  unique "address port";
  min-elements 1;
  ordered-by user;
  description
    "A non-empty user-ordered list of endpoints for this NETCONF
     server to try to connect to. Defining more than one enables
     high-availability.";
  leaf name {
    type string;
    description
      "An arbitrary name for this endpoint.";
  }
  leaf address {
    type inet:host;
    mandatory true;
    description
      "The IP address or hostname of the endpoint. If a
      hostname is configured and the DNS resolution results
      in more than one IP address, the NETCONF server
      will process the IP addresses as if they had been
      explicitly configured in place of the hostname.";
  }
  leaf port {
    type inet:port-number;
    description
      "The IP port for this endpoint. The NETCONF server will
      use the IANA-assigned well-known port (set via a refine
      statement when uses) if no value is specified.";
  }
}
}
}

<CODE ENDS>

4. Design Considerations

   Editorial: this section is a hold over from before, previously called
   "Objectives". It was only written two support the "server" (not the
The question is if it's better to add the missing "client" parts, or remove this section altogether.

The primary purpose of the YANG modules defined herein is to enable the configuration of the NETCONF client and servers. This scope includes the following objectives:

4.1. Support all NETCONF transports

The YANG module should support all current NETCONF transports, namely NETCONF over SSH [RFC6242], NETCONF over TLS [RFC7589], and to be extensible to support future transports as necessary.

Because implementations may not support all transports, the modules should use YANG "feature" statements so that implementations can accurately advertise which transports are supported.

4.2. Enable each transport to select which keys to use

Servers may have a multiplicity of host-keys or server-certificates from which subsets may be selected for specific uses. For instance, a NETCONF server may want to use one set of SSH host-keys when listening on port 830, and a different set of SSH host-keys when calling home. The data models provided herein should enable configuration of which keys to use on a per-use basis.

4.3. Support authenticating NETCONF clients certificates

When a certificate is used to authenticate a NETCONF client, there is a need to configure the server to know how to authenticate the certificates. The server should be able to authenticate the client's certificate either by using path-validation to a configured trust anchor or by matching the client-certificate to one previously configured.

4.4. Support mapping authenticated NETCONF client certificates to usernames

When a client certificate is used for TLS client authentication, the NETCONF server must be able to derive a username from the authenticated certificate. Thus the modules defined herein should enable this mapping to be configured.

4.5. Support both listening for connections and call home

The NETCONF protocols were originally defined as having the server
opening a port to listen for client connections. More recently the
NETCONF working group defined support for call-home ([RFC8071]),
enabling the server to initiate the connection to the client. Thus
the modules defined herein should enable configuration for both
listening for connections and calling home. Because implementations
may not support both listening for connections and calling home, YANG
"feature" statements should be used so that implementation can
accurately advertise the connection types it supports.

4.6. For Call Home connections

The following objectives only pertain to call home connections.

4.6.1. Support more than one NETCONF client

A NETCONF server may be managed by more than one NETCONF client. For
instance, a deployment may have one client for provisioning and
another for fault monitoring. Therefore, when it is desired for a
server to initiate call home connections, it should be able to do so
to more than one client.

4.6.2. Support NETCONF clients having more than one endpoint

A NETCONF client managing a NETCONF server may implement a high-
availability strategy employing a multiplicity of active and/or
passive endpoint. Therefore, when it is desired for a server to
initiate call home connections, it should be able to connect to any
of the client's endpoints.

4.6.3. Support a reconnection strategy

Assuming a NETCONF client has more than one endpoint, then it becomes
necessary to configure how a NETCONF server should reconnect to the
client should it lose its connection to one the client's endpoints.
For instance, the NETCONF server may start with first endpoint
defined in a user-ordered list of endpoints or with the last
endpoints it was connected to.

4.6.4. Support both persistent and periodic connections

NETCONF clients may vary greatly on how frequently they need to
interact with a NETCONF server, how responsive interactions need to be, and how many simultaneous connections they can support. Some clients may need a persistent connection to servers to optimize real-time interactions, while others prefer periodic interactions in order to minimize resource requirements. Therefore, when it is necessary for server to initiate connections, it should be configurable if the connection is persistent or periodic.

4.6.5. Reconnection strategy for periodic connections

The reconnection strategy should apply to both persistent and periodic connections. How it applies to periodic connections becomes clear when considering that a periodic "connection" is a logical connection to a single server. That is, the periods of unconnectedness are intentional as opposed to due to external reasons. A periodic "connection" should always reconnect to the same server until it is no longer able to, at which time the reconnection strategy guides how to connect to another server.

4.6.6. Keep-aliases for persistent connections

If a persistent connection is desired, it is the responsibility of the connection initiator to actively test the "aliveness" of the connection. The connection initiator must immediately work to reestablish a persistent connection as soon as the connection is lost. How often the connection should be tested is driven by NETCONF client requirements, and therefore keep-alive settings should be configurable on a per-client basis.

4.6.7. Customizations for periodic connections

If a periodic connection is desired, it is necessary for the NETCONF server to know how often it should connect. This frequency determines the maximum amount of time a NETCONF client may have to wait to send data to a server. A server may connect to a client before this interval expires if desired (e.g., to send data to a client).

5. Security Considerations
A denial of service (DoS) attack MAY occur if the NETCONF server limits the maximum number of NETCONF sessions it will accept (i.e. the 'max-sessions' field in the ietf-netconf-server module is not zero) and either the "hello-timeout" or "idle-timeout" fields in ietf-netconf-server module have been set to indicate the NETCONF server should wait forever (i.e. set to zero).

The YANG module defined in this document uses groupings defined in [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 module defined in this document is 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) [RFC6536] 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 this YANG module that are writable/creatable/deletable (i.e., config true, which is the default). These data nodes may be considered sensitive or vulnerable in some network environments. Write operations (e.g., edit-config) to these data nodes without proper protection can have a negative effect on network operations. These are the subtrees and data nodes and their sensitivity/vulnerability:

NONE

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

NONE
Some of the RPC operations in this YANG module 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:

NONE

6. IANA Considerations

6.1. The IETF XML Registry

This document registers two URIs in the IETF XML registry [RFC3688]. Following the format in [RFC3688], the following registrations are requested:

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

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 [RFC7950]. Following the format in [RFC7950], the following registrations are requested:

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

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

7. Acknowledgements
The authors would like to thank for following for lively discussions on list and in the halls (ordered by last name): Andy Bierman, Martin Bjorklund, Benoit Claise, Mehmet Ersue, Balazs Kovacs, David Lamparter, Alan Luchuk, Ladislav Lhotka, Radek Krejci, Tom Petch, Phil Shafer, Sean Turner, and Bert Wijnen.

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

8. References

8.1. Normative References


[RFC6242] Wasserman, M., "Using the NETCONF Protocol over Secure


8.2. Informative References


Appendix_A. Change Log

A.1. server-model-09 to 00

  o This draft was split out from draft-ietf-netconf-server-model-09.
  o Added in previously missing ietf-netconf-client module.
  o Added in new features 'listen' and 'call-home' so future transports can be augmented in.

A.2. 00 to 01

  o Renamed "keychain" to "keystore".

A.3. 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 accomodate new groupings in the ssh/tls drafts.

A.4. 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).

A.5. 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.
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