Abstract

This document defines two YANG modules, one module to configure a
RESTCONF client and the other module to configure a RESTCONF server.
Both modules support the TLS transport protocol with both standard
RESTCONF and RESTCONF 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-tls-client-server
- I-D.ietf-netconf-http-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
- "BBBB" --> 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:

- "2019-11-02" --> the publication date of this draft

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

- 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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This Internet-Draft will expire on May 4, 2020.

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1. Introduction

This document defines two YANG [RFC7950] modules, one module to configure a RESTCONF client and the other module to configure a RESTCONF server [RFC8040]. Both modules support the TLS [RFC8446].
transport protocol with both standard RESTCONF and RESTCONF Call Home connections [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.

2. The RESTCONF Client Model

The RESTCONF client model presented in this section supports both clients initiating connections to servers, as well as clients listening for connections from servers calling home.

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

2.1. Tree Diagram

The following tree diagram [RFC8340] provides an overview of the data model for the "ietf-restconf-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.
grouping restconf-client-listen-stack-grouping
 +-- (transport)
  +--:(http) {http-listen}?
  |  +-- FIXME
  +--:(https) {https-listen}?
  +-- https
   +-- tcp-server-parameters
   |  +--u tcps:tcp-server-grouping
   |  +-- tls-client-parameters
   |  +--u tlsc:tls-client-grouping
   +-- http-client-parameters
   |  +--u httpc:http-client-grouping
   +-- restconf-client-parameters

grouping restconf-client-app-grouping
 +-- initiate! {https-initiate}?
  |  +-- restconf-server* [name]
  |  +-- name? string
  |  +-- endpoints
  |  |  +-- endpoint* [name]
  |  |  |  +-- name? string
  |  |  +--u restconf-client-initiate-stack-grouping
  |  +-- connection-type
  |  |  +-- (connection-type)
  |  |  |  +--:(persistent-connection)
  |  |  |  |  +-- persistent!
  |  |  |  +--:(periodic-connection)
  |  |  |  |  +-- period? uint16
  |  |  |  |  +-- anchor-time? yang:date-and-time
  |  |  |  |  +-- idle-timeout? uint16
  |  +-- reconnect-strategy
  |  |  +-- start-with? enumeration
  |  |  +-- max-attempts? uint8
  +-- listen! {http-listen or https-listen}?
   +-- idle-timeout? uint16
   +-- endpoint* [name]
   |  +-- name? string
   +--u restconf-client-listen-stack-grouping

2.2. Example Usage

The following example illustrates configuring a RESTCONF client to initiate connections, as well as listening for call-home connections.

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].
<?xml version="1.0" encoding="UTF-8"?>
  <!-- RESTCONF servers to initiate connections to -->
  <initiate>
    <restconf-server>
      <name>corp-fw1</name>
      <endpoints>
        <endpoint>
          <name>corp-fw1.example.com</name>
          <https>
            <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>
            <tls-client-parameters>
              <client-identity>
                <local-definition>
                  <algorithm>rsa2048</algorithm>
                  <private-key>base64encodedvalue==</private-key>
                  <public-key>base64encodedvalue==</public-key>
                  <cert>base64encodedvalue==</cert>
                </local-definition>
              </client-identity>
              <server-authentication>
                <ca-certs>
                  <truststore-reference>explicitly-trusted-server-ca\-certs</truststore-reference>
                </ca-certs>
                <server-certs>
                  <truststore-reference>explicitly-trusted-server-ce\-certs</truststore-reference>
                </server-certs>
              </server-authentication>
              <keepalives>
                <max-wait>30</max-wait>
                <max-attempts>3</max-attempts>
              </keepalives>
            </tls-client-parameters>
            <http-client-parameters>
              <client-identity>
                <basic>
                </basic>
              </client-identity>
            </http-client-parameters>
          </https>
        </endpoint>
      </endpoints>
    </restconf-server>
  </initiate>
</restconf-client>
<user-id>bob</user-id>
<password>secret</password>
</basic>
</client-identity>
</http-client-parameters>
<https>
</endpoint>
<endpoint>
<name>corp-fw2.example.com</name>
<https>
<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>
<tls-client-parameters>
<client-identity>
<local-definition>
<algorithm>rsa2048</algorithm>
<private-key>base64encodedvalue==</private-key>
<public-key>base64encodedvalue==</public-key>
<cert>base64encodedvalue==</cert>
</local-definition>
</client-identity>
<server-authentication>
<ca-certs>
<truststore-reference>explicitly-trusted-server-ca\-certs</truststore-reference>
</ca-certs>
<server-certs>
<truststore-reference>explicitly-trusted-server-ce\rts</truststore-reference>
</server-certs>
</server-authentication>
<keepalives>
<max-wait>30</max-wait>
<max-attempts>3</max-attempts>
</keepalives>
</tls-client-parameters>
</https>
<http-client-parameters>
<client-identity>
<basic>
<user-id>bob</user-id>
<password>secret</password>
</basic>
<client-identity>
</http-client-parameters>
</https>
</endpoints>
<connection-type>
<persistent/>
</connection-type>
</restconf-server>
</initiate>

<!-- endpoints to listen for RESTCONF Call Home connections on -->
<listen>
<endpoint>
  <name>Intranet-facing listener</name>
  <https>
    <tcp-server-parameters>
      <local-address>11.22.33.44</local-address>
    </tcp-server-parameters>
    <tls-client-parameters>
      <client-identity>
        <local-definition>
          <algorithm>rsa2048</algorithm>
          <private-key>base64encodedvalue==</private-key>
          <public-key>base64encodedvalue==</public-key>
          <cert>base64encodedvalue==</cert>
        </local-definition>
      </client-identity>
      <server-authentication>
        <ca-certs>
          <truststore-reference>explicitly-trusted-server-ca-certs</truststore-reference>
        </ca-certs>
        <server-certs>
          <truststore-reference>explicitly-trusted-server-certs</truststore-reference>
        </server-certs>
        <server-authentication>
        </server-authentication>
      </server-certs>
    </tls-client-parameters>
    <http-client-parameters>
      <client-identity>
        <basic>
          <user-id>bob</user-id>
          <password>secret</password>
        </basic>
      </client-identity>
    </http-client-parameters>
  </https>
</endpoint>
</listen>
2.3. YANG Module

This YANG module has normative references to [RFC6991], [RFC8040], and [RFC8071], [I-D.kwatsen-netconf-tcp-client-server], [I-D.ietf-netconf-tls-client-server], and [I-D.kwatsen-netconf-http-client-server].

<CODE BEGINS> file "ietf-restconf-client@2019-11-02.yang"

module ietf-restconf-client {
  yang-version 1.1;
  prefix rcc;

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

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

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

  import ietf-tls-client {
    prefix tlsc;
    reference
      "RFC BBBB: YANG Groupings for TLS Clients and TLS Servers";
  }

  import ietf-http-client {
    prefix httpc;
    reference
      "RFC CCCC: YANG Groupings for HTTP Clients and HTTP Servers";
  }

<CODE ENDS>
organization
"IETF NETCONF (Network Configuration) Working Group";

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

description
"This module contains a collection of YANG definitions
for configuring RESTCONF 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’,
‘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 2019-11-02 {
  description
    "Initial version";
  reference
    "RFC XXXX: RESTCONF Client and Server Models";
}

// Features

feature https-initiate {
  description
    "The ‘https-initiate’ feature indicates that the RESTCONF
    client supports initiating HTTPS connections to RESTCONF
    servers. This feature exists as HTTPS might not be a
mandatory to implement transport in the future.

reference
"RFC 8040: RESTCONF Protocol"
}

feature http-listen {
    description
    "The ‘https-listen’ feature indicates that the RESTCONF client
    supports opening a port to listen for incoming RESTCONF
    server call-home connections. This feature exists as not
    all RESTCONF clients may support RESTCONF call home."
    reference
    "RFC 8071: NETCONF Call Home and RESTCONF Call Home"
}

feature https-listen {
    description
    "The ‘https-listen’ feature indicates that the RESTCONF client
    supports opening a port to listen for incoming RESTCONF
    server call-home connections. This feature exists as not
    all RESTCONF clients may support RESTCONF call home."
    reference
    "RFC 8071: NETCONF Call Home and RESTCONF Call Home"
}

// Groupings

grouping restconf-client-grouping {
    description
    "A reusable grouping for configuring a RESTCONF client
    without any consideration for how underlying transport
    sessions are established.

    This grouping currently doesn’t define any nodes."
}

grouping restconf-client-initiate-stack-grouping {
    description
    "A reusable grouping for configuring a RESTCONF client
    ‘initiate’ protocol stack for a single connection."

    choice transport {
        mandatory true;
        description
        "Selects between available transports. This is a
        ‘choice’ statement so as to support additional
        transport options to be augmented in."

        case https {
if-feature "https-initiate";
container https {
  description
  "Specifies HTTPS-specific 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 "443";
        description
        "The RESTCONF client will attempt to connect to the IANA-assigned well-known port value for 'https' (443) 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;
  }
  container http-client-parameters {
    description
    "A wrapper around the HTTP client parameters to avoid name collisions."
    uses httpc:http-client-grouping;
  }
  container restconf-client-parameters {
    description
    "A wrapper around the HTTP client parameters to avoid name collisions."
    uses rcc:restconf-client-grouping;
  }
}
} // restconf-client-initiate-stack-grouping
grouping restconf-client-listen-stack-grouping {
    description "A reusable grouping for configuring a RESTCONF client
    'listen' protocol stack for a single connection.";
    choice transport {
        mandatory true;
        description "Selects between available transports. This is a
        'choice' statement so as to support additional
        transport options to be augmented in.";
        case http {
            if-feature "http-listen";
            container FIXME {
                description "FIXME";
            }
        }
        case https {
            if-feature "https-listen";
            container https {
                description "HTTPS-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 "4336";
                            description "The RESTCONF client will listen on the IANA-
                            assigned well-known port for 'restconf-ch-tls'
                            (4336) 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;
                }
                container http-client-parameters {

                }
            }
        }
    }
}

Watsen                     Expires May 4, 2020                 
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description
"A wrapper around the HTTP client parameters to avoid name collisions."
uses httpc:http-client-grouping;
}
container restconf-client-parameters {
  description
  "A wrapper around the RESTCONF client parameters to avoid name collisions."
  uses rcc:restconf-client-grouping;
}
}
} // restconf-client-listen-stack-grouping

grouping restconf-client-app-grouping {
  description
  "A reusable grouping for configuring a RESTCONF client application that supports both 'initiate' and 'listen' protocol stacks for a multiplicity of connections."
  container initiate {
    if-feature "https-initiate";
    presence "Enables client to initiate TCP connections";
    description
    "Configures client initiating underlying TCP connections.";
    list restconf-server {
      key "name";
      min-elements 1;
      description
      "List of RESTCONF servers the RESTCONF client is to maintain simultaneous connections with.";
      leaf name {
        type string;
        description
        "An arbitrary name for the RESTCONF server.";
      }
    }
    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 RESTCONF client to try to connect to in sequence. Defining more than one enables high-availability.";
      }
      leaf port {
        type integer;
        description
        "The port number of the RESTCONF server to connect to."
      }
      leaf hostname {
        type string;
        description
        "The host name of the RESTCONF server to connect to.";
      }
      leaf mutual-auth {
        type boolean;
        default false;
        description
        "Enable mutual authentication when connecting to the RESTCONF server."
      }
    }
  }
  list restconf-server {
    key "name";
    min-elements 1;
    description
    "List of RESTCONF servers the RESTCONF client is to maintain simultaneous connections with.";
    leaf name {
      type string;
      description
      "An arbitrary name for the RESTCONF server.";
    }
  }
  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 RESTCONF client to try to connect to in sequence. Defining more than one enables high-availability.";
    }
    leaf port {
      type integer;
      description
      "The port number of the RESTCONF server to connect to."
    }
    leaf hostname {
      type string;
      description
      "The host name of the RESTCONF server to connect to.";
    }
    leaf mutual-auth {
      type boolean;
      default false;
      description
      "Enable mutual authentication when connecting to the RESTCONF server."
    }
  }


leaf name {
    type string;
    description
    "An arbitrary name for this endpoint."
}
uses restconf-client-initiate-stack-grouping;
}
}
container connection-type {
    description
    "Indicates the RESTCONF client’s preference for how
    the RESTCONF 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
                RESTCONF server. If the connection goes down,
                immediately start trying to reconnect to the
                RESTCONF server, using the reconnection strategy.

                This connection type minimizes any RESTCONF server
to RESTCONF 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 RESTCONF server.

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

                The RESTCONF client SHOULD gracefully close
the underlying TLS 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 the underlying TCP session may remain idle. A TCP session will be dropped if it is idle for an interval longer than this number of seconds If set to zero, then the RESTCONF client will never drop a session because it is idle.";
}

container reconnect-strategy {
  description
  "The reconnection strategy directs how a RESTCONF client reconnects to a RESTCONF server, after
discovering its connection to the server has dropped, even if due to a reboot. The RESTCONF 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. RESTCONF 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 RESTCONF server’s endpoints the RESTCONF client should start with when trying to connect to the RESTCONF server.";
}

leaf max-attempts {
  type uint8 {
    range "1..max";
  }
  default "3";
  description
  "Specifies the number times the RESTCONF client tries to connect to a specific endpoint before moving on to the next endpoint in the list (round robin).";
}
} // initiate

container listen {
  if-feature "http-listen or https-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 an underlying TCP session may remain idle. A TCP 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 RESTCONF connections.";
    leaf name {
      type string;
      description
        "An arbitrary name for the RESTCONF listen endpoint.";
    }
    uses restconf-client-listen-stack-grouping;
  }
}

} // restconf-client-app-grouping

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

container restconf-client {
  uses restconf-client-app-grouping;
  description
    "Top-level container for RESTCONF client configuration.";
}

<CODE ENDS>
3. The RESTCONF Server Model

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

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

3.1. Tree Diagram

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

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

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

module: ietf-restconf-server
    ++--rw restconf-server
        +---u restconf-server-app-grouping

    grouping restconf-server-grouping
        ++-- client-identification
            +-- cert-maps
                +---u x509c2n:cert-to-name

    grouping restconf-server-listen-stack-grouping
        ++-- (transport)
            +--:(http) (http-listen)?
                ++-- http
                    |    ++-- external-endpoint!
                    |        |    |    ++-- address inet:ip-address
                    |        |    |    ++-- port? inet:port-number
                    |    ++-- tcp-server-parameters
                    |        |    |    ++-- u tcpserver:tcp-server-grouping
                    |        |    |    ++-- http-server-parameters
                    |        |    |    ++-- https https:https-server-grouping
                    |        |    |    +-- restconf-server-parameters
                    |        |    |        |    ++-- u rcs:restconf-server-grouping
                    |    ++--:(https) (https-listen)?
                        ++-- https
                            ++-- tcp-server-parameters
                                |    ++-- u tcpserver:tcp-server-grouping
                                ++-- tls-server-parameters
grouping restconf-server-callhome-stack-grouping
+- (transport)
  +--:(https) (https-listen)?
    +- https
      +- tcp-client-parameters
        |  +-- tcp-client-grouping
        |     +-- tls-server-parameters
        |     |  +-- tls-server-grouping
        |     +- http-server-parameters
        |    |  +-- http-server-grouping
        |    +- restconf-server-parameters
        |       +-- rcs:restconf-server-grouping
      |    +- restconf-server-callhome-stack-grouping
    |        +-- listen! {http-listen or https-listen}? 
    |           |  +-- endpoint* [name]
    |           |     |  +- name? string
    |           |     +-- restconf-server-listen-stack-grouping
    |           +- call-home! {https-call-home}? 
    |               |  +-- restconf-client* [name]
    |               |     |  +- name? string
    |               |     +-- endpoints
    |               |        |  +-- endpoint* [name]
    |               |        |     |  +- name? string
    |               |        |     +-- restconf-server-callhome-stack-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

3.2. Example Usage

The following example illustrates configuring a RESTCONF server to listen for RESTCONF client connections, as well as configuring call-home to one RESTCONF client.
This example is consistent with the examples presented in Section 2 of [I-D.ietf-netconf-trust-anchors] and Section 3.2 of [I-D.ietf-netconf-keystore].

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

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

    <!-- endpoints to listen for RESTCONF connections on -->
    <listen>
        <endpoint>
            <name>netconf/tls</name>
            <https>
                <tcp-server-parameters>
                    <local-address>11.22.33.44</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>
                            <truststore-reference>explicitly-trusted-client-ca-certs</truststore-reference>
                        </ca-certs>
                        <client-certs>
                            <truststore-reference>explicitly-trusted-client-certs</truststore-reference>
                        </client-certs>
                    </client-authentication>
                    <http-server-parameters>
                        <server-name>foo.example.com</server-name>
                        <protocol-versions>
                            <protocol-version>HTTP/1.1</protocol-version>
                            <protocol-version>HTTP/2.0</protocol-version>
                        </protocol-versions>
                    </http-server-parameters>
                </tls-server-parameters>
            </https>
        </endpoint>
    </listen>
</restconf-server>
<cert-maps>
  <cert-to-name>
    <id>1</id>
    <fingerprint>11:0A:05:11:00</fingerprint>
    <map-type>x509c2n:specified</map-type>
    <name>scooby-doo</name>
  </cert-to-name>
  <cert-to-name>
    <id>2</id>
    <map-type>x509c2n:san-any</map-type>
  </cert-to-name>
</cert-maps>

<!-- call home to a RESTCONF client with two endpoints -->
<call-home>
  <restconf-client>
    <name>config-manager</name>
    <endpoints>
      <endpoint>
        <name>east-data-center</name>
        <https>
          <tcp-client-parameters>
            <remote-address>east.example.com</remote-address>
          </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/>
            </client-authentication>
            <ca-certs>
              <truststore-reference>explicitly-trusted-client-ca\ncerts</truststore-reference>
            </ca-certs>
            <client-certs>
              <truststore-reference>explicitly-trusted-client-certs</truststore-reference>
            </client-certs>
          </tls-server-parameters>
        </https>
      </endpoint>
    </endpoints>
  </restconf-client>
</call-home>
</client-authentication>
</tls-server-parameters>
<http-server-parameters>
  <server-name>foo.example.com</server-name>
  <protocol-versions>
    <protocol-version>HTTP/1.1</protocol-version>
    <protocol-version>HTTP/2.0</protocol-version>
  </protocol-versions>
</http-server-parameters>
<restconf-server-parameters>
  <client-identification>
    <cert-maps>
      <cert-to-name>
        <id>1</id>
        <fingerprint>11:0A:05:11:00</fingerprint>
        <map-type>x509c2n:specified</map-type>
        <name>scooby-doo</name>
      </cert-to-name>
      <cert-to-name>
        <id>2</id>
        <map-type>x509c2n:san-any</map-type>
      </cert-to-name>
    </cert-maps>
  </client-identification>
</restconf-server-parameters>
</https>
</endpoint>
<endpoint>
  <name>west-data-center</name>
  <https>
    <tcp-client-parameters>
      <remote-address>west.example.com</remote-address>
    </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>
      <required/>
      <ca-certs>
        <truststore-reference>explicitly-trusted-client-ca\ncerts</truststore-reference>
      </ca-certs>
    </tls-server-parameters>
  </https>
</endpoint>
<client-certs>
  <truststore-reference>explicitly-trusted-client-certs</truststore-reference>
</client-certs>
</client-authentication>
</tls-server-parameters>
<http-server-parameters>
  <server-name>foo.example.com</server-name>
  <protocol-versions>
    <protocol-version>HTTP/1.1</protocol-version>
    <protocol-version>HTTP/2.0</protocol-version>
  </protocol-versions>
</http-server-parameters>
<restconf-server-parameters>
  <client-identification>
    <cert-maps>
      <cert-to-name>
        <id>1</id>
        <fingerprint>11:0A:05:11:00</fingerprint>
        <map-type>x509c2n:specified</map-type>
        <name>scooby-doo</name>
      </cert-to-name>
      <cert-to-name>
        <id>2</id>
        <map-type>x509c2n:san-any</map-type>
      </cert-to-name>
    </cert-maps>
  </client-identification>
</restconf-server-parameters>
</https>
</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>
</restconf-client>
</call-home>
</restconf-server>
3.3. YANG Module

This YANG module has normative references to [RFC6991], [RFC7407], [RFC8040], [RFC8071], [I-D.kwatsen-netconf-tcp-client-server], [I-D.ietf-netconf-tls-client-server], and [I-D.kwatsen-netconf-http-client-server].

<CODE BEGINS> file "ietf-restconf-server@2019-11-02.yang"

module ietf-restconf-server {
  yang-version 1.1;
  namespace "urn:ietf:params:xml:ns:yang:ietf-restconf-server";
  prefix rcs;

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

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

  import ietf-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-tls-server {
    prefix tlss;
    reference
      "RFC BBBB: YANG Groupings for TLS Clients and TLS Servers";
  }

</CODE ENDS>
import ietf-http-server {
  prefix https;
  reference
    "RFC CCCC: YANG Groupings for HTTP Clients and HTTP Servers";
}

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

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

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

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  as authors of the code. All rights reserved.

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

  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’,
  ‘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 2019-11-02 {
  description
    "Initial version";
  reference
// Features

feature http-listen {
    description
    "The 'http-listen' feature indicates that the RESTCONF server supports opening a port to listen for incoming RESTCONF over TCP client connections, whereby the TLS connections are terminated by an external system.";
    reference
    "RFC 8040: RESTCONF Protocol";
}

feature https-listen {
    description
    "The 'https-listen' feature indicates that the RESTCONF server supports opening a port to listen for incoming RESTCONF over TLS client connections, whereby the TLS connections are terminated by the server itself.";
    reference
    "RFC 8040: RESTCONF Protocol";
}

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

// Groupings

grouping restconf-server-grouping {
    description
    "A reusable grouping for configuring a RESTCONF server without any consideration for how underlying transport sessions are established.

    Note that this grouping uses a fairly typical descendent node name such that a stack of 'uses' statements will have name conflicts. It is intended that the consuming data model will resolve the issue by wrapping the 'uses' statement in a container called, e.g., 'restconf-server-parameters'. This model purposely does
not do this itself so as to provide maximum flexibility to consuming models.

container client-identification {  // FIXME: if-feature?
  description
  "Specifies a mapping through which clients MAY be identified (i.e., the RESTCONF username) from a supplied certificate. Note that a client MAY alternatively be identified via an alternate authentication scheme (e.g., HTTP-level authentication).";
  container cert-maps {
    uses x509c2n:cert-to-name {
      refine "cert-to-name/fingerprint" {
        mandatory false;
        description
        "A 'fingerprint' value does not need to be specified when the 'cert-to-name' mapping is independent of fingerprint matching. A 'cert-to-name' having no fingerprint value will match any client certificate and therefore should only be present at the end of the user-ordered 'cert-to-name' list."
      }
    }
    description
    "The cert-maps container is used by TLS-based RESTCONF servers (even if the TLS sessions are terminated externally) to map the RESTCONF client’s presented X.509 certificate to a RESTCONF username. If no matching and valid cert-to-name list entry can be found, then the RESTCONF server MUST close the connection, and MUST NOT accept RESTCONF messages over it.";
    reference
    "RFC 7407: A YANG Data Model for SNMP Configuration.";
  }
}

grouping restconf-server-listen-stack-grouping {
  description
  "A reusable grouping for configuring a RESTCONF server 'listen' protocol stack for a single connection."
  choice transport {
    mandatory true;
    description
    "Selects between available transports. This is a 'choice' statement so as to support additional"
transport options to be augmented in.

case http {
  if-feature "http-listen";
  container http {
    description
    "Configures RESTCONF server stack assuming that
    TLS-termination is handled externally.";
    container external-endpoint {
      presence
      "Specifies configuration for an external endpoint.";
      description
      "Identifies contact information for the external
      system that terminates connections before passing
      them thru to this server (e.g., a network address
      translator or a load balancer). These values have
      no effect on the local operation of this server, but
      may be used by the application when needing to
      inform other systems how to contact this server.";
      leaf address {
        type inet:ip-address;
        mandatory true;
        description
        "The IP address or hostname of the external system
        that terminates incoming RESTCONF client
        connections before forwarding them to this
        server.";
      }
      leaf port {
        type inet:port-number;
        default "443";
        description
        "The port number that the external system listens
        on for incoming RESTCONF client connections that
        are forwarded to this server. The default HTTPS
        port (443) is used, as expected for a RESTCONF
        connection.";
      }
    }
  }
}

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 "80";
      description
      "The RESTCONF server will listen on the IANA-
      assigned well-known port value for ‘http’
case https {
    if-feature "https-listen";
    container https {
        description
        "Configures RESTCONF server stack assuming that
        TLS-termination is handled internally.";
        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 "443";
                    description
                    "The RESTCONF server will listen on the IANA-
                    assigned well-known port value for 'https'
                    (443) 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; /* { FIXME: commented out since auth could also be external. */
    refine "client-authentication" {
        must ‘ca-certs or client-certs’;
        description
"NETCONF/TLS servers MUST validate client certificates."

container http-server-parameters {
  description
  "A wrapper around the HTTP server parameters to avoid name collisions.";
  uses https:http-server-grouping;
}

container restconf-server-parameters {
  description
  "A wrapper around the RESTCONF server parameters to avoid name collisions.";
  uses rcs:restconf-server-grouping;
}

grouping restconf-server-callhome-stack-grouping {
  description
  "A reusable grouping for configuring a RESTCONF server 'call-home' protocol stack, for a single connection.";
  choice transport {
    mandatory true;
    description
    "Selects between available transports. This is a 'choice' statement so as to support additional transport options to be augmented in.";
    case https {
      if-feature "https-listen";
      container https {
        description
        "Configures RESTCONF server stack assuming that TLS-termination is handled internally.";
        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 "4336";
              description
              "The RESTCONF server will attempt to connect to the IANA-assigned well-known port for 'restconf-ch-tls' (4336) if no
value is specified."
}
}
}
}
container tls-server-parameters {
  description
  "A wrapper around the TLS server parameters to avoid name collisions.";
  uses tls:tls-server-grouping; /*
   FIXME: commented out since auth could also be external.
   ^-- need a better 'must' expression?
   refine "client-authentication" {
     must 'ca-certs or client-certs';
     description
     "NETCONF/TLS servers MUST validate client certificates.";
   }*/
}
container http-server-parameters {
  description
  "A wrapper around the HTTP server parameters to avoid name collisions.";
  uses https:http-server-grouping;
}
container restconf-server-parameters {
  description
  "A wrapper around the RESTCONF server parameters to avoid name collisions.";
  uses rcs:restconf-server-grouping;
}
}
}
}


grouping restconf-server-app-grouping {
  description
  "A reusable grouping for configuring a RESTCONF server application that supports both 'listen' and 'call-home' protocol stacks for a multiplicity of connections.";
  container listen {
    if-feature "http-listen or https-listen";
    presence
    "Enables the RESTCONF server to listen for RESTCONF client connections.";
    description "Configures listen behavior";
    list endpoint {
key "name";
min-elements 1;
description
"List of endpoints to listen for RESTCONF connections."
leaf name {
  type string;
description
  "An arbitrary name for the RESTCONF listen endpoint."
}
uses restconf-server-listen-stack-grouping;
}
}
container call-home {
  if-feature "https-call-home";
presence
  "Enables the RESTCONF server to initiate the underlying
  transport connection to RESTCONF clients."
description "Configures call-home behavior";
list restconf-client {
  key "name";
  min-elements 1;
description
  "List of RESTCONF clients the RESTCONF server is to
  maintain simultaneous call-home connections with."
leaf name {
  type string;
description
  "An arbitrary name for the remote RESTCONF client."
}
}
container endpoints {
description
  "Container for the list of endpoints."
list endpoint {
  key "name";
  min-elements 1;
  ordered-by user;
description
  "User-ordered list of endpoints for this RESTCONF
  client. Defining more than one enables high-
  availability."
leaf name {
  type string;
description
  "An arbitrary name for this endpoint."
}
uses restconf-server-callhome-stack-grouping;
}
container connection-type {
  description
  "Indicates the RESTCONF server’s preference for how the
  RESTCONF 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 RESTCONF
        client. If the connection goes down, immediately
        start trying to reconnect to the RESTCONF server,
        using the reconnection strategy.

        This connection type minimizes any RESTCONF
        client to RESTCONF server 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 RESTCONF client.

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

        The RESTCONF client SHOULD gracefully close
        the underlying TLS connection upon completing
        planned activities. If the underlying TLS
        connection is not closed gracefully, the
        RESTCONF server MUST immediately attempt
        to reestablish the connection.

        In the case that the previous connection is
        still active (i.e., the RESTCONF client has not
        closed it yet), establishing a new connection
        is NOT RECOMMENDED.";
      }
    }
  }
}
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{4}-\d{2}-\d{2}T\d{2}:\d{2}\[\+-\]\d{2}:\d{2}Z';
  }
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
the underlying TCP session may remain idle.
A TCP 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 reconnect-strategy {
description
"The reconnection strategy directs how a RESTCONF server
reconnects to a RESTCONF client after discovering its
connection to the client has dropped, even if due to a
reboot. The RESTCONF 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. RESTCONF
      servers SHOULD be able to remember the last
      endpoint connected to across reboots."
  }
  enum random-selection {
    description "Indicates that reconnections should start with
      a random endpoint."
  }
  default "first-listed";
}
description "Specifies which of the RESTCONF client’s endpoints
the RESTCONF server should start with when trying
to connect to the RESTCONF client."

leaf max-attempts {
  type uint8 {
    range "1..max";
  }
  default "3";
  description "Specifies the number times the RESTCONF server tries
to connect to a specific endpoint before moving on to
the next endpoint in the list (round robin)."
}

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

container restconf-server {
uses restconf-server-app-grouping;

description
   "Top-level container for RESTCONF server configuration."
;
}

}

</CODE ENDS>

4. Security Considerations

The YANG module defined in this document uses groupings defined in [I-D.kwatsen-netconf-tcp-client-server], [I-D.ietf-netconf-tls-client-server], and [I-D.kwatsen-netconf-http-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.

5. IANA Considerations

5.1. 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:

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.

5.2. 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-restconf-client
prefix: ncc
reference: RFC XXXX

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

6. References

6.1. Normative References

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

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

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


6.2. Informative References

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


Appendix A. Expanded Tree Diagrams

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

The following tree diagram [RFC8340] provides an overview of the data model for the "ietf-restconf-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 2.1 for a tree diagram that illustrates what the module looks like without all the "grouping" statements expanded.

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

module: ietf-restconf-client
  +--rw restconf-client
    |   +--rw initiate! {https-initiate}?
    |      +--rw restconf-server* [name]
    |      |   +--rw name                  string
    |      |   +--rw endpoints
    |      |      +--rw endpoint* [name]
    |      |         +--rw name           string
    |      |         +--rw (transport)
    |      |         +--:(https) {https-initiate}?
    |      +--rw https
    |         +--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
    |                 |              +--: iasa:asymmetric-alg
\ning-request
|     |
| binary
|     +--:(keystore)
|       {keystore-supported}?
|       +---rw keystore-reference
|       +---rw asymmetric-key?
|           |       ks:asymmetric-key
\ef
\fref
|     |     +---rw certificate? lea
\pported)?
\t-cms
|     |     +----n certificate-expiration
\tion
|     |     +--- expiration-date
|       yang:date-and
\ptime
|     |     +--:(truststore)
|       {truststore-supported}
\x509-certificates)?
|     |     +---rw truststore-reference?
|       ts:certificates-ref
|     |     +---rw server-certs!
\pported)?
\t-cms
|     |     +----n certificate-expiration
\tion
|     |     +--- expiration-date
|       yang:date-and
\ptime
|     |     +--:(truststore)
|       {truststore-supported}
\x509-certificates)?
|     |     +---rw truststore-reference?
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|     |              |  |                   ts:certificates-ref
|     |              |  +--rw hello-params
|     |              |  |       {tls-client-hello-params-config}\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 http-client-parameters
|     |              |  +--rw client-identity
|     |              |  |  +--rw (auth-type)
|     |              |  |     +--:(basic)
|     |              |  |     |  +--rw basic {basic-auth}?
|     |              |  |     |     +--rw user-id     string
|     |              |  |     |     +--rw password    string
|     |              |  +--rw proxy-server! {proxy-connect}?
|     |              |  +--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
|     |              |  |     |       |       iasa:asymmetric
|     |              |  |     |       |       \ic-algorithm-type
|     |              |  |     |       \at?
|     |              |  |     |       +--rw public-key-form\-identityref

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trust-anchors

--= certificate-

-- expiration-

yang:date-and-time

--:(truststore)

{truststore-supplied, X509-certificates}?

--rw truststore-reference

ts:certificate

--rw hello-params

(tls-client-hello-params-configuration)

--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 proxy-client-identity

--rw (auth-type)

--=(basic)

--rw basic {basic-auth}?

--rw user-id

string

--rw password

string

--rw restconf-client-parameters

--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! (http-listen or https-listen)?
++-rw idle-timeout?  uint16
++-rw endpoint* [name]
    ++-rw name          string
    ++-rw (transport)
        +--:(http) {http-listen}?
            |     +--rw FIXME
        +--:(https) {https-listen}?
            ++-rw https
                ++-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
                    |                |                        |                |    +--:(local)
                    |    |                |                        |                |        |        {local-definitions-supported}?
                    |    |                |                        |                |        |                        ++-rw algorithm
                    |    |                |                        |                |        |                        |     iasa:asymmetric-algorithm
                    |    |                |                        |                |        |                        ++-rw public-key-format?
                    |                |                        |                |    identityref
                    |                |                        |                |    ++-rw public-key
                    |                        |                |                |    binary
                    |                        |                |                |    ++-rw private-key-format?
                    |                        |                |                |    identityref
                    |                        |                |                |    ++-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)
                    |                        |                |                |        |        |        |    ++-rw symmetric-key
                    |                        |                |                |        |        |        |    ++-rw keyref
                    |                        |                |                |        |        |        |    (keystore-supported)
                    |                        |                |                |        |        |        |    +--:(asymmetric-key-ref)
                    |                        |                |                |        |        |        |    ++-rw keyref

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```
\orithm-type
|     |  |     |     +--rw public-key-format?
|     |  |     |     |       identityref
|     |  |     |     +--rw public-key
|     |  |     |     |       binary
|     |  |     |     +--rw private-key-format?
|     |  |     |     |       identityref
|     |  |     |     +--rw (private-key-type)
|     |  |     |     |  +--:(private-key)
|     |  |     |     |     +--rw private-key?
|     |  |     |     |     |       binary
|     |  |     |     |     +--:(hidden-private-key)
|     |  |     |     |     +--rw hidden-private-

\key?
|     |  |     |     |     |     | empty

\key
|     |  |     |     +--rw encrypted-private-

\te-key
|     |  |     |     +--rw (key-type)
|     |  |     |     |       ++--:(symmetric-\n
\key-ref)
|     |  |     |     +--rw asymmetric\n
\tric-key-ref? leafref
|     |  |     |     |     |     | (key\n
\store-supported)?
|     |  |     |     +--:(asymmetric\n
\-key-ref)
|     |  |     |     +--rw asymmetric\n
\tric-key-ref? leafref
|     |  |     |     |     |     | (key\n
\store-supported)?
|     |  |     |     +--rw value?
|     |  |     |     |       binary
|     |  |     |     +--rw cert?
|     |  |     |     |       end-entity-cert-cms
|     |  |     |     +--n certificate-expiration
|     |  |     |     |         +-- expiration-date
|     |  |     |     |         |       yang:date-and-ti\n
\me
|     |  |     |     ++--x generate-certificate-

\signing-request
|     |  |     |     +--w input
|     |  |     |     |     |     | ++--w subject
|     |  |     |     |     |     |     | binary
|     |  |     |     |     |     |     | ++--w attributes?
|     |  |     |     |     |     |     |     | binary
|     |  |     |     |     |     |     |     | ++ro output
```
A.2. Expanded Tree Diagram for 'ietf-restconf-server'

The following tree diagram [RFC8340] provides an overview of the data model for the "ietf-restconf-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 3.1 for a tree diagram that illustrates what the module looks like without all the "grouping" statements expanded.

====== NOTE: '
' line wrapping per BCP XXX (RFC XXXX) =====
---rw keepalives! {keepalives-supported}?
  +--rw idle-time      uint16
  +--rw max-probes     uint16
  +--rw probe-interval uint16
---rw http-server-parameters
  +--rw server-name?   string
---rw protocol-versions
  | +--rw protocol-version* enumeration
---rw client-authentication!
  +--rw (required-or-optional)
    ++-:(required)
    |   +--rw required?
    |       empty
    ++-:(optional)
    |   +--rw optional?
    |       empty
  +--rw (local-or-external)
    ++-:(local)
    |   {local-client-auth-supported}?
    |   +--rw users
    |     +--rw user* [user-id]
    |        +--rw user-id    string
    |     +--rw (auth-type)?
    |        +--:(basic)
    |            +--rw basic {basic-auth}?
    |            |      +--rw user-id?
    |            |          string
    |            +--rw password?
    |                  ianach:crypto-\watsen
---rw (required-or-optional)
  ++-:(external)
  |   {external-client-auth-supported}\watsen
---rw restconf-server-parameters
  +--rw client-identification
  | +--rw cert-maps
  |    +--rw cert-to-name* [id]
  |        +--rw id     uint32
  |        +--rw fingerprint?
  |            |      x509c2n:tls-fingerprint
  |        +--rw map-type identityref
  |        +--rw name    string
  ++-:(https) {https-listen}?
  |   +--rw https
  |     |   +--rw tcp-server-parameters
  |     |     |   +--rw local-address inet:ip-address
g-request

---x generate-certificate-signin

---w input
  ---w subject binary
  ---w attributes? binary

---ro output
  ---ro certificate-signing-request

---(keystore) {keystore-supported}?
  ---rw keystore-reference
    ---rw asymmetric-key?
      ks:asymmetric-key-ref
    ---rw certificate? leafref

---rw client-authentication!
  ---rw (required-or-optional)
    ---:(required)
      ---rw required?
        empty
    ---:(optional)
      ---rw optional?
        empty
  ---rw (local-or-external)
    ---:(local)
      {local-client-auth-supported}?
      ---rw ca-certs!
      ---rw (local-or-truststore)
        ---:(local)
          {local-definitions-supported}?

---rw local-definition
  ---rw cert*
    trust-anchor-certificate

---n certificate-expiration
  --- expiration-date
    yang:date-and-time

---(truststore)
  {truststore-supported}
  ---truststore-reference?
    ts:certificates-ref
  ---rw client-certs!
    ---rw (local-or-truststore)
      ---:(local)
++rw local-definition
  +--rw algorithm
    isa:asymmetric-alg

orithm-type
++rw public-key-format?
  | identityref
++rw public-key
  | binary
++rw private-key-format?
  | identityref
++rw (private-key-type)
  +--:(private-key)
    +--rw private-key?
      | binary
    +--:(hidden-private-key)
      | ++rw hidden-private-

key?
empty
++-(encrypted-private-k

ey)
++rw encrypted-privat

te-key
++rw (key-type)
  +--:(symmetric-

ke-ref)
ric-key-ref?  leafref
  +--rw symmetric-

store-supported)?
tric-key-ref?  leafref
  +--rw asymmetric-

store-supported)?
  +--rw value?
    binary
++rw cert?
  | end-entity-cert-cms
  +--n certificate-expiration
    +-- expiration-date
      yang:date-and-ti
me
++-x generate-certificate-

signing-request
  +--w input
    +--w subject
binary

---w attributes?

binary

---ro output

---ro certificate-sig

ning-request

binary

---:(keystore)

{keystore-supported}?

---rw keystore-reference

---rw asymmetric-key?

ks:asymmetric-key-r

ef

---rw certificate? lea\n
fref

---rw client-authentication!

---rw (required-or-optional)

---:(required)

---rw required?

empty

---:(optional)

---rw optional?

empty

---rw (local-or-external)

---:(local)

{local-client-auth-suppo\n
rted)?

---rw ca-certs!

---rw (local-or-truststore)

---:(local)

{local-definiti\n
ons-supported)?

---rw local-definition

---rw cert*

trust-anch\n
or-cert-cms

expiration

--- expiration-

date

--- ".yang:da"

te-and-time

---:(truststore)

{truststore-sup\n
ported,x509-certificates)?

---rw truststore-refe\n
rence?
es-ref
|     |     |     |     +--rw client-certs!
|     |     |     |     +--rw (local-or-truststore)
|     |     |     |     +--:(local)
|     |     |     |             {local-definition}
|     |     |     |     +--rw local-definition
|     |     |     |             +--rw cert*
|     |     |     |             |     trust-anchor
|     |     |     |             +--:(truststore)
|     |     |     |                 {truststore-supported,x509-certificates}?
|     |     |     |                 +--rw truststore-reference?
|     |     |     |                 ts:certificates-ref
|     |     |     |         +--:(external)
|     |     |     |             {external-client-auth-supported}?
|     |     |     |             +--rw client-auth-defined-elsewhere?
|     |     |     |             empty
|     |     |     |             +--rw hello-params
|     |     |     |             |             {tls-server-hello-params-config}
|     |     |     |             }
|     |     |     +--rw hello-params
|     |     |             {tls-server-hello-params-config}
|     |     +--rw max-wait?
|     |             uint16
|     +--rw max-attempts?
|             uint8
|     +--rw http-server-parameters
|     +--rw server-name?
|             string
|     +--rw protocol-versions
|             +--rw protocol-version*   enumeration
|             +--rw client-authentication!
|             +--rw (required-or-optional)
|             |     +--:(required)
|             |             +--rw required?
Appendix B. Change Log

B.1. 00 to 01

  o Renamed "keychain" to "keystore".

B.2. 01 to 02

  o Filled in previously missing 'ietf-restconf-client' module.

  o Updated the ietf-restconf-server module to accommodate new grouping 'ietf-tls-server-grouping'.

B.3. 02 to 03

  o Refined use of tls-client-grouping to add a must statement indicating that the TLS client must specify a client-certificate.

  o Changed restconf-client??? to be a grouping (not a container).

B.4. 03 to 04

  o Added RFC 8174 to Requirements Language Section.

  o Replaced refine statement in ietf-restconf-client to add a mandatory true.

  o Added refine statement in ietf-restconf-server to add a must statement.

  o Now there are containers and groupings, for both the client and server models.

  o Now tree diagrams reference ietf-netmod-yang-tree-diagrams

  o Updated examples to inline key and certificates (no longer a leafref to keystore)

B.5. 04 to 05

  o Now tree diagrams reference ietf-netmod-yang-tree-diagrams

  o Updated examples to inline key and certificates (no longer a leafref to keystore)
B.6. 05 to 06

o Fixed change log missing section issue.

o Updated examples to match latest updates to the crypto-types, trust-anchors, and keystore drafts.

o Reduced line length of the YANG modules to fit within 69 columns.

B.7. 06 to 07

o removed "idle-timeout" from "persistent" connection config.

o Added "random-selection" for reconnection-strategy’s "starts-with" enum.

o Replaced "connection-type" choice default (persistent) with "mandatory true".

o Reduced the periodic-connection’s "idle-timeout" from 5 to 2 minutes.

o Replaced reconnect-timeout with period/anchor-time combo.

B.8. 07 to 08

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

B.9. 08 to 09

o Corrected use of "mandatory true" for "address" leaves.

o Updated examples to reflect update to groupings defined in the keystore draft.

o Updated to use groupings defined in new TCP and HTTP drafts.

o Updated copyright date, boilerplate template, affiliation, and folding algorithm.

B.10. 09 to 10

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

- 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 '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 better describe behavior when connections are not closed gracefully.
- 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.//)
- In ietf-restconf-server, Added 'http-listen' (not https-listen) choice, to support case when server is behind a TLS-terminator.
- Refactored server module to be more like other 'server' models. If folks like it, will also apply to the client model, as well as to both the netconf client/server models. Now the 'restconf-server-grouping' is just the RC-specific bits (i.e., the "demux" container minus the container), 'restconf-server-
[listen|callhome]-stack-grouping’ is the protocol stack for a single connection, and ‘restconf-server-app-grouping’ is effectively what was before (both listen+callhome for many inbound/outbound endpoints).

B.14.  13 to 14

- Updated examples to reflect ietf-crypto-types change (e.g., identities --> enumerations)
- Adjusting from change in TLS client model (removing the top-level ‘certificate’ container).
- Added "external-endpoint" to the "http-listen" choice in ietf-restconf-server.

B.15.  14 to 15

- Added missing "or https-listen" clause in a "must" expression.
- Refactored the client module similar to how the server module was refactored in -13. Now the ‘restconf-client-grouping’ is just the RC-specific bits, the ‘restconf-client-[initiate|listen]-stack-grouping’ is the protocol stack for a single connection, and ‘restconf-client-app-grouping’ is effectively what was before (both listen+callhome for many inbound/outbound endpoints).

B.16.  15 to 16

- Added refinement to make "cert-to-name/fingerprint" be mandatory false.
- Commented out refinement to "tls-server-grouping/client-authentication" until a better "must" expression is defined.
- Updated restconf-client example to reflect that http-client-grouping no longer has a "protocol-version" leaf.

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