RESTCONF Client and Server Models
draft-ietf-netconf-restconf-client-server-14

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
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 show the nodes defined by "grouping" statements used by this module.

Please see Appendix A.1 for a tree diagram that illustrates what the module looks like with all the "grouping" statements expanded.
module: ietf-restconf-client
  +--rw restconf-client
  +---u restconf-client-grouping

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

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

<restconf-client
  xmlns="urn:ietf:params:xml:ns:yang:ietf-restconf-client">
  <!-- 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>
            </tls-client-parameters>
          </https>
        </endpoint>
      </endpoints>
    </restconf-server>
    <server-authentication>
      <ca-certs>explicitly-trusted-server-ca-certs</ca-certs>
      <server-certs>explicitly-trusted-server-certs</server-certs>
    </server-authentication>
    <keepalives>
      <max-wait>30</max-wait>
      <max-attempts>3</max-attempts>
    </keepalives>
  </initiate>
</restconf-client>
</keepalives>
</tls-client-parameters>
<http-client-parameters>
<protocol-version>HTTP/1.1</protocol-version>
</http-client-parameters>
</client-identity>
</http-client-parameters>
</https>
</endpoint>
<endpoint>
<name>corp-fw2.example.com</name>
<https>
</https>
</tcp-client-parameters>
</remote-address>corp-fw2.example.com</remote-address>
</keepalives>
</tcp-client-parameters>
</keepalives>
</tcp-client-parameters>
</server-authentication>
</client-identity>
</server-authentication>
</keepalives>
</tls-client-parameters>
</server-authentication>
</keepalives>
</tls-client-parameters>
</http-client-parameters>
</protocol-version>HTTP/1.1</protocol-version>
</client-identity>
</basic>
</client-identity>
</http-client-parameters>
</https>
</endpoint>
<endpoint>
<name>corp-fw2.example.com</name>
<http-client-parameters>
<protocol-version>HTTP/1.1</protocol-version>
</http-client-parameters>
</client-identity>
</http-client-parameters>
</https>
</endpoint>
<endpoint>
<name>corp-fw2.example.com</name>
<https>
</https>
</tcp-client-parameters>
</remote-address>corp-fw2.example.com</remote-address>
</keepalives>
</tcp-client-parameters>
</keepalives>
</tcp-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>explicitly-trusted-server-ca-certs</ca-certs>
<server-certs>explicitly-trusted-server-certs</server-certs>
</server-authentication>
<keepalives>
<max-wait>30</max-wait>
<max-attempts>3</max-attempts>
</keepalives>
</tls-client-parameters>
</http-client-parameters>
<protocol-version>HTTP/1.1</protocol-version>
</client-identity>
</basic>
</client-identity>
</tcp-client-parameters>
</keepalives>
</tcp-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>explicitly-trusted-server-ca-certs</ca-certs>
<server-certs>explicitly-trusted-server-certs</server-certs>
</server-authentication>
<keepalives>
<max-wait>30</max-wait>
<max-attempts>3</max-attempts>
</keepalives>
</tls-client-parameters>
</http-client-parameters>
<protocol-version>HTTP/1.1</protocol-version>
</client-identity>
</basic>
<user-id>bob</user-id>
<password>secret</password>
</basic>
</client-identity>
</http-client-parameters>
</https>
</endpoint>
</endpoints>
<connection-type>
<persistent/>
</connection-type>
</restconf-server>
</initiate>

<!-- endpoints to listen for RESTCONF Call Home connections on -->
<listen>
<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>explicitly-trusted-server-ca-certs</ca-certs>
<server-certs>explicitly-trusted-server-certs</server-certs>
</server-authentication>
</tls-client-parameters>
</http-client-parameters>
</https>
</endpoint>
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@2019-07-02.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";
  }

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

<CODE ENDS>
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', 'SHALL NOT', 'SHOULD', 'SHOULD NOT', 'RECOMMENDED', 'NOT RECOMMENDED', 'MAY', and 'OPTIONAL' in this document are to be interpreted as described in BCP 14 (RFC 2119) (RFC 8174) when, and only when, they appear in all capitals, as shown here."

revision 2019-07-02 {
  description
    "Initial version";
  reference
    "RFC XXXX: 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 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
    "Top-level grouping for RESTCONF client configuration.";
    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
            initiate connections to in parallel.";
            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 name {
                    type string;
                    description
                    "An arbitrary name for this endpoint.";
                }
            }
        }
    }
}

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;
      }
    }
  }
} // transport
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.";
}
} // periodic-connection
} // connection-type
} // connection-type
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).";
}
} // reconnect-strategy
} // restconf-server
} // initiate

container listen {
  if-feature "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 then 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.";
    }
    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
                "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.";
                        }
                    }
                }
            }
        }
    }
}
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
          |       ++- http-server-parameters
          |          ++- https:https-server-grouping
          |             ++- restconf-server-parameters
          |                +++-u rcs:restconf-server-grouping
          |             ++-(https) (https-listen)?
          |    ++- https
          |      ++- tcp-server-parameters
          |        ++- tls-server-parameters
          |        ++- http-server-parameters
          |        +++-u https:https-server-grouping
          |        ++- restconf-server-parameters
          |        +++-u rcs:restconf-server-grouping

  grouping restconf-server-callhome-stack-grouping
    ++- (transport)
      ++-(https) (https-listen)?
        ++- https
          |  ++- tcp-client-parameters
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 XX (RFC XXXX) =========
<!-- 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>
          <client-authentication>
            <required/>
            <ca-certs>explicitly-trusted-client-ca-certs</ca-certs>
            <client-certs>explicitly-trusted-client-certs</client-certs>
          </client-authentication>
        </server-identity>
        <client-identification>
          <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-identification>
      </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>
    </https>
  </endpoint>
</listen>
> 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/>
            <ca-certs>explicitly-trusted-client-ca-certs</ca-certs>
            <client-certs>explicitly-trusted-client-certs</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>
      </https>
    </endpoint>
  </endpoints>
</restconf-client>
<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-identification>
</restconf-server-parameters>
</https>
</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>
</client-authentication>
<required/>
<ca-certs>explicitly-trusted-client-ca-certs</ca-certs>
<client-certs>explicitly-trusted-client-certs</client-certs>
</tls-server-parameters>
</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: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-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@2019-07-02.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 8040: Common YANG Data Types";
    }

    connection-parameter {  
        name "https";
        id "default";
        cert-maps {
            cert-to-name {
                id "default";
                fingerprint B3:4F:A1:8C:54;
                map-type "x509c2n:specified";
                name "scooby-doo";
            }
        }
        client-identification {
            connection-type {
                periodic {
                    idle-timeout 300;
                    period 60;
                }
            }
            reconnect-strategy {
                start-with "last-connected";
                max-attempts 3;
            }
        }
    }
}

<CODE ENDS>
"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";
}

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."
Copyright (c) 2019 IETF Trust and the persons identified as authors of the code. All rights reserved.

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

The key words ‘MUST’, ‘MUST NOT’, ‘REQUIRED’, ‘SHALL’, ‘SHALL NOT’, ‘SHOULD’, ‘SHOULD NOT’, ‘RECOMMENDED’, ‘NOT RECOMMENDED’, ‘MAY’, and ‘OPTIONAL’ in this document are to be interpreted as described in BCP 14 (RFC 2119) when, and only when, they appear in all capitals, as shown here.

revision 2019-07-02 {
  description
    "Initial version";
  reference
    "RFC XXXX: RESTCONF Client and Server Models";
}

// 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 fairly typical descendent node names such that a stack of ‘uses’ statements will have name conflicts. It is intended that the consuming data model will resolve the issue (e.g., by wrapping the ‘uses’ statement in a container called ‘restconf-server-parameters’). This model purposely does not do this itself so as to provide maximum flexibility to consuming models."
  
  container client-identification {
    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 HTTP-level authentication schema. This configuration does not necessitate clients send a certificate (that can be controlled via the ietf-restconf-server module)."
    
    container cert-maps {
      uses x509c2n:cert-to-name;
      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
    }
  }
}
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 {
          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 server.",
          }
        }
      }
    }
  }
}

"RFC 7407: A YANG Data Model for SNMP Configuration.";
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' (80) if no value is specified.";
        }
    }
}

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;
}
}

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;
}
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 tlss:tls-server-grouping;
}
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 and for many connections.";
container listen {
if-feature "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
    initiate call-home connections to in parallel.";
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.";
    }
  }

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}\+\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 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)."
}
}
} // restconf-client
} // call-home
} // restconf-server-app-grouping

// 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.";
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 to 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 XX (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 
                                    | (local-or-keystore) 
                                    | (local) 
                                    | {local-definitions-supported}? 
                                    +--rw local-definition 
                                        +--rw algorithm 
                                            asymmetric-key-algorithm
```
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| | | | | | | +--rw keystore-reference
| | | | | |   +--rw asymmetric-key?
| | | | | |     ks:asymmetric-key-r\n\ef
| | | | | |   +--rw certificate?
\eref
| | | | | | | | | | +--rw server-authentication
| | | | | | | | | |   +--rw ca-certs?
| | | | | | | | | |   ts:certificates-ref
| | | | | | | | | |   {ts:x509-certificates}?
| | | | | | | | | | +--rw server-certs?
| | | | | | | | | |   ts:certificates-ref
| | | | | | | | | |   {ts:x509-certificates}?
| | | | | | | | | | +--rw hello-params
| | | | | | | | | |   {tls-client-hello-params-config}
| | | | | | | | | | ?
| | | | | | | | | | | | | | +--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 protocol-version?  enumeration
| | | | | | | | | | | +--rw client-identity
| | | | | | | | | | |   +--rw (auth-type)?
| | | | | | | | | | |     +--:(basic)
| | | | | | | | | | |     | +--rw basic (basic-auth)?
| | | | | | | | | | |     |   +--rw user-id?  string
| | | | | | | | | | |     |   +--rw password?  string
| | | | | | | | | | |     +--:(bearer)
| | | | | | | | | | |     | +--rw bearer (bearer-auth)?
| | | | | | | | | | |     |   +--rw token?  string
| | | | | | | | | | |     +--:(digest)
| | | | | | | | | | |     | +--rw digest (digest-auth)?
| | | | | | | | | | |     |   +--rw username?  string
| | | | | | | | | | |     |   +--rw password?  string
| | | | | | | | | | |     +--:(hoba)
| | | | | | | | | | |     | +--rw hoba (hoba-auth)?
| | | | | | | | | | |     +--:(mutual)
| | | | | | | | | | |     | +--rw mutual (mutual-auth)?
| | | | | | | | | | |     +--:(negotiate)
| | | | | | | | | | |     | +--rw negotiate
| | | | | | | | | | |     |   {negotiate-auth}?
| | | | | | | | | | |     +--:(oauth)
| | | | | | | | | | |     | +--rw oauth (oauth-auth)?
```plaintext
+--rw scram-sha-1
    +--rw scram-sha-1
        (scram-sha-1-auth)?
+--rw scram-sha-256
    +--rw scram-sha-256
        (scram-sha-256-auth)?
    +--rw vapid
        +--rw vapid (vapid-auth)?
+--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)
            +--rw local-definition
                +--rw algorithm
                    asymmetric-key
            +--rw public-key
                binary
                +--rw (private-key-type)
            +--rw (private-key)
                binary
                +--:(hidden-private-key)
            +--rw hidden-private-key
                empty
                +--:(encrypted-private-key)
```
\vate-key)
|     |                    |  |     |     |     +--rw encrypted
\-private-key
|     |                    |  |     |     |        +--rw (key-t
\ype)
|     |                    |  |     |     |        |  +--:(symm
\metric-key-ref)
|     |                    |  |     |     |        |  |  +--rw 
\symmetric-key-ref? leafref
|     |                    |  |     |     |        |  |        
  {keystore-supported}?
|     |                    |  |     |     |        |  +--:(asym
\metric-key-ref)
|     |                    |  |     |     |        |     +--rw 
\asymmetric-key-ref? leafref
|     |                    |  |     |     |        |     \ 
\ {keystore-supported}?
|     |                    |  |     |     |        |          bina
\ry
|     |                    |  |     |     |        |          cert?
\rt-cms
|     |                    |  |     |     |        |          end-entity-ce
\iration
|     |                    |  |     |     |        |          certificate-exp
\and-time
|     |                    |  |     |     |        |          expiration-date
\icate-signing-request
|     |                    |  |     |     |        |          generate-certif
\s?
|     |                    |  |     |     |        |          binary
\e-signing-request
|     |                    |  |     |     |        |          certifica
\d)?
|     |                    |  |     |     |        |          keystore-reference
\-key-ref
|     |                    |  |     |     |        |          certificate?

leafref

  +--rw server-authentication
  |    +--rw ca-certs?
  |    |       ts:certificates-ref
  |    |       {ts:x509-certificates}?
  |    +--rw server-certs?
  |         ts:certificates-ref
  |         {ts:x509-certificates}?
  +--rw hello-params
       {tls-client-hello-params-\config}?

  +--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 user-id?    string
       +--rw password?   string

  +--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! {https-listen}?
          +--rw idle-timeout?   uint16
          +--rw endpoint* [name]
             +--rw name   string
             +--rw (transport)
              +--:(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
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|     +--rw max-probes        uint16
|     +--rw probe-interval    uint16
+--rw tls-client-parameters
     +--rw client-identity
        +--rw (local-or-keystore)
           +--{(local)
             |    {local-definitions-supported}?
             |    +--rw local-definition
             |    |    +--rw algorithm
             |    |    |    asymmetric-key-algorithm-t
             |    |    +--rw public-key
             |    |    |    binary
             |    +--rw (private-key-type)
             |    |    +--{(private-key)
             |    |    |    +--rw private-key?
             |    |    |    |    binary
             |    |    |    +--{(hidden-private-key)
             |    |    |    |    +--rw hidden-private-key?
             |    |    |    |    |    empty
             |    |    |    +--{(encrypted-private-key)
             |    |    |    |    +--rw encrypted-private-key
             |    |    |    |    |    +--rw (key-type)
             |    |    |    |    |    |    +--{(symmetric-key-ref}\n
\f

\y-ref? leafref
\y-ref? leafref
\\supported}?
\\supported}?
\\supported}?
\\supported}?
\\supported}?
\g-request

Watsen                   Expires January 3, 2020               [Page 45]
|     +--:(keystore) {keystore-supported}?     binary
|     ++-rw keystore-reference
|        +++-rw asymmetric-key?
|           |        ks:asymmetric-key-ref
|           +--rw certificate? leafref
|        ++-rw server-authentication
|           +--rw ca-certs? ts:certificates-ref
|           |        {ts:x509-certificates}?
|           +--rw server-certs? ts:certificates-ref
|           |        {ts:x509-certificates}?
|        +++-rw hello-params
|           {tls-client-hello-params-config}?
|           ++-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 protocol-version? enumeration
|           +--rw client-identity
|           |        +++-rw (auth-type)?
|           |           +++-:(basic)
|           |           |        +++-rw basic {basic-auth}?
|           |           |           |        +++-rw user-id? string
|           |           |           +--rw password? string
|           |           +++-:(bearer)
|           |           |        +++-rw bearer {bearer-auth}?
|           |           |           +--rw token? string
|           |           +++-:(digest)
|           |           |        +++-rw digest {digest-auth}?
|           |           |           |        +++-rw username? string
|           |           |           +--rw password? string
|           |           +++-:(hoba)
|           |           |        +++-rw hoba {hoba-auth}?
|           |           +++-:(mutual)
|           |           |        +++-rw mutual {mutual-auth}?
|           |           +++-:(negotiate)
|           |           |        +++-rw negotiate {negotiate-auth}?
|           |           +++-:(oauth)
|           |           |        +++-rw oauth {oauth-auth}?
|           |           +++-:(scram-sha-1)
|           |           |        +++-rw scram-sha-1 {scram-sha-1-auth}?
|           |           +++-:(scram-sha-256)
|           |           |        +++-rw scram-sha-256
\-key-ref)
\tric-key-ref?  leafref
\store-supported)?
\\me
\signing-request
\\ning-request
\\ef
\\eref
\\)?
\-key-ref
\tric-key-ref?
\store-supported?
\me
\signing-request
\\ning-request
\\ef
\\eref
\\)?
\-key-ref
\tric-key-ref?
\store-supported?
\me
\signing-request
\\ning-request
\\ef
\\eref
\\)?
### 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 XX (RFC XXXX) ===========
empty

++-rw (local-or-external)
  +++-(local)
    {local-client-auth-supported}?
    +++-rw users
      +++-rw user* [name]
        +++-rw name string
        +++-rw password? ianach:encrypt
        +++-:(external)
          {external-client-auth-supported}?

++-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
      +++-rw local-port? inet:port-number
      +++-rw keepalives! {keepalives-supported}?
        +++-rw idle-time uint16
        +++-rw max-probes uint16
        +++-rw probe-interval uint16
    +++-rw tls-server-parameters
      +++-rw server-identity
        +++-rw (local-or-keystore)
          +++-(local)
            {local-definitions-supported}?
            +++-rw local-definition
              +++-rw algorithm
                | asymmetric-key-algorithm-t
              +++-rw public-key
                | binary
              +++-rw (private-key-type)
                +++-(private-key)
                  | +++-rw private-key? binary
                +++-(hidden-private-key)
                  | +++-rw hidden-private-key?
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---rw cert-to-name* [id]
    +--rw id            uint32
    +--rw fingerprint
        |       x509c2n:tls-fingerprint
    +--rw map-type      identityref
    +--rw name          string

---rw call-home! {https-call-home}?

---rw restconf-client* [name]
    +--rw name        string

---rw endpoints
    +--rw endpoint* [name]
        +--rw name        string
        +--rw (transport)
            +--:(https) {https-listen}?
                +--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-server-parameters
                        +--rw server-identity
                            +--:(local)
                                {local-definitions-supported}?
                                +--rw local-definition
                                    +--rw algorithm
                                        asymmetric-key-algorithm
                                +--:(private-key)
                                    +--rw public-key
                                        binary
                                    +--:(private-key-type)
                                        +--:(private-key)
                                            +--rw private-key?
                                                binary
                                            +--:(hidden-private-key)
                                                +--rw hidden-private-key?
                                            +--:(encrypted-private-key)
                                                empty
                            +--:(hidden-private-key)
encrypted-private key

(key-type)

(symmetric-key)

(key)

(asymmetric-key)

(key)

(value?)

(binary)

cert?

(end-entity-cert-cms)

(certificate-expiration)

(expiration-date)

(yang:date-and-time)

generate-certificate-signing-request

(input)

(subject)

(attributes?)

(output)

(binary)

(certificate-signing-request)

(keystore)

(keystore-supported)

(keystore-reference)

(asymmetric-key?)

(ks:asymmetric-key-ref)

(client-authentication)

(required-or-optional)

(required)

(required)

(empty)
++-(optional)
  ++-rw optional?
    empty
  ++-rw (local-or-external)
    ++-(local)
      {local-client-auth-supported}

rted)?
  ++-rw ca-certs?
    ts:certificates-ref
    {ts:x509-certificates}?
  ++-rw client-certs?
    ts:certificates-ref
    {ts:x509-certificates}?
  ++-(external)
    {external-client-auth-supported}

pported)?
  ++-rw client-auth-defined-elsewhere?

where?
  empty
  ++-rw hello-params
    {tls-server-hello-params-config}?

+--rw tls-versions
  +--rw tls-version* identityref
  ++-rw cipher-suites
    +--rw cipher-suite* identityref
  ++-rw keepalives!
    {tls-server-keepalives}?
  ++-rw max-wait? uint16
  ++-rw max-attempts? uint8

+--rw 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}

rted)?
  +--rw users
    +--rw user* [name]
## Appendix B. Change Log

### B.1. 00 to 01

- Renamed "keychain" to "keystore".

### B.2. 01 to 02

- Filled in previously missing 'ietf-restconf-client' module.
- 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.
- Replaced "connection-type" choice default (persistent) with "mandatory true".
- Reduced the periodic-connection’s "idle-timeout" from 5 to 2 minutes.
- Replaced reconnect-timeout with period/anchor-time combo.

B.8. 07 to 08

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

B.9. 08 to 09

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

B.10. 09 to 10

- Reformatted YANG modules.

B.11. 10 to 11

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

B.12. 11 to 12

- Removed the ‘must’ statement limiting keepalives in periodic connections.
- Updated models and examples to reflect removal of the "demux" containers in the imported models.
o Updated the "periodic-connection" description statements to better describe behavior when connections are not closed gracefully.

o Updated text to better reference where certain examples come from (e.g., which Section in which draft).

o In the server model, commented out the "must ‘pinned-ca-certs or pinned-client-certs’" statement to reflect change made in the TLS draft whereby the trust anchors MAY be defined externally.

o Replaced the ‘listen’, ‘initiate’, and ‘call-home’ features with boolean expressions.

B.13 12 to 13

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

o In ietf-restconf-server, added ‘http-listen’ (not https-listen) choice, to support case when server is behind a TLS-terminator.

o 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

o Updated examples to reflect ietf-crypto-types change (e.g., identities --> enumerations)

o Adjusting from change in TLS client model (removing the top-level ‘certificate’ container).

o Added "external-endpoint" to the "http-listen" choice in ietf-restconf-server.

Acknowledgements

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

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