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RESTCONF Client and Server Models
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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:

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

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

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

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

- o "2018-10-22" --> the publication date of this draft

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

- o Appendix A. Change Log

Status of This Memo

This Internet-Draft is submitted in full conformance with the provisions of BCP 78 and BCP 79.

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1. Introduction

This document defines two YANG [RFC7950] modules, one module to configure a 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.

This model, like that presented in [I-D.ietf-netconf-netconf-client-server], is designed to support any number of possible transports. RESTCONF only supports the TLS transport currently, thus this model only supports the TLS transport.

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

YANG feature statements are used to enable implementations to advertise which parts of the model the 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. Just the container is displayed below, but there is also a reusable grouping called "restconf-client-grouping" that the container is using.

[Note: '\' line wrapping for formatting only]

```

module: ietf-restconf-client
  +--rw restconf-client
    +--rw initiate! {initiate}?
      +--rw restconf-server* [name]
        +--rw name          string
        +--rw endpoints
          +--rw endpoint* [name]
            +--rw name          string
            +--rw (transport)
              +--:(tls) {tls-initiate}?
                +--rw tls
                  +--rw address          inet:host
                  +--rw port?            inet:port-number
                +--rw client-identity
                  +--rw (auth-type)
                    +--:(certificate)
                      +--rw certificate
                        +--rw (local-or-keystore)
                          +--:(local)
                            {local-keys-suppor\
ted}?
                            +--rw algorithm?
                              |
                              asymmetric-key-e\
ncryption-algorithm-ref
                              +--rw public-key?
                              |
                              binary
                              +--rw private-key?
                              |
                              union
                              +---x generate-hidden-key
                              |
                              +---w input
                              |
                              +---w algorithm
                              |
                              asymmetric\
-key-encryption-algorithm-ref
                              +---x install-hidden-key
                              |
                              +---w input
                              |
                              +---w algorithm
                              |
                              asymmetric\
-key-encryption-algorithm-ref

```



```

+--rw endpoint* [name]
  +--rw name          string
  +--rw (transport)
    +--:(tls) {tls-listen}?
      +--rw tls
        +--rw address?          inet:ip-address
        +--rw port?             inet:port-number
        +--rw client-identity
          | +--rw (auth-type)
          | | +--:(certificate)
          | | | +--rw certificate
          | | | | +--rw (local-or-keystore)
          | | | | | +--:(local) {local-keys-supported}\
          | | }?
          | |
          | | +--rw algorithm?
          | | | asymmetric-key-encrypt\
          | |
          | | +--rw public-key?
          | | | binary
          | | | +--rw private-key?
          | | | | union
          | | | | +---x generate-hidden-key
          | | | | | +---w input
          | | | | | | +---w algorithm
          | | | | | | | asymmetric-key-e\
          | | | }?
          | |
          | | +---x install-hidden-key
          | | | +---w input
          | | | | +---w algorithm
          | | | | | asymmetric-key-e\
          | | | }?
          | |
          | | +---w public-key?  bin\
          | |
          | | +---w private-key? bin\
          | |
          | | +--rw cert?
          | | | end-entity-cert-cms
          | | | +---n certificate-expiration
          | | | | +-- expiration-date
          | | | | | yang:date-and-time
          | | | | | +--:(keystore) {keystore-supporte\
          | | | }?
          | |
          | | +--rw reference?
          | | | ks:asymmetric-key-cert\
          | |
          | | +--rw server-auth
          | | | +--rw pinned-ca-certs?
          | | | | ta:pinned-certificates-ref

```

```

|         {ta:x509-certificates}?
|--rw pinned-server-certs?
|         ta:pinned-certificates-ref
|         {ta:x509-certificates}?
|--rw hello-params
|         {tls-client-hello-params-config}?
|--rw tls-versions
|   |--rw tls-version*   identityref
|--rw cipher-suites
|   |--rw cipher-suite*  identityref

```

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 3.2 of [I-D.ietf-netconf-keystore].

[Note: '\ ' line wrapping for formatting only]

```

<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>
          <tls>
            <address>corp-fw1.example.com</address>
            <client-identity>
              <certificate>
                <algorithm xmlns:ct="urn:ietf:params:xml:ns:yang:iet\
f-crypto-types">ct:rsa2048</algorithm>
                <private-key>base64encodedvalue==</private-key>
                <public-key>base64encodedvalue==</public-key>
                <cert>base64encodedvalue==</cert>
              </certificate>
            </client-identity>
            <server-auth>
              <pinned-ca-certs>explicitly-trusted-server-ca-certs</p\
inned-ca-certs>
              <pinned-server-certs>explicitly-trusted-server-certs</\
pinned-server-certs>

```

```

        </server-auth>
    </tls>
    <connection-type>
        <persistent/>
    </connection-type>
</endpoint>
<endpoint>
    <name>corp-fw2.example.com</name>
    <tls>
        <address>corp-fw2.example.com</address>
        <client-identity>
            <certificate>
                <algorithm xmlns:ct="urn:ietf:params:xml:ns:yang:ietf-
f-crypto-types">ct:rsa2048</algorithm>
                <private-key>base64encodedvalue==</private-key>
                <public-key>base64encodedvalue==</public-key>
                <cert>base64encodedvalue==</cert>
            </certificate>
        </client-identity>
        <server-auth>
            <pinned-ca-certs>explicitly-trusted-server-ca-certs</p\
inned-ca-certs>
            <pinned-server-certs>explicitly-trusted-server-certs</\
pinned-server-certs>
        </server-auth>
    </tls>
    <connection-type>
        <persistent/>
    </connection-type>
</endpoint>
</endpoints>
</restconf-server>
</initiate>

<!-- endpoints to listen for RESTCONF Call Home connections on -->
<listen>
    <endpoint>
        <name>Intranet-facing listener</name>
        <tls>
            <address>11.22.33.44</address>
            <client-identity>
                <certificate>
                    <algorithm xmlns:ct="urn:ietf:params:xml:ns:yang:ietf-cr\
ypto-types">ct:rsa2048</algorithm>
                    <private-key>base64encodedvalue==</private-key>
                    <public-key>base64encodedvalue==</public-key>
                    <cert>base64encodedvalue==</cert>
                </certificate>
            </client-identity>
        </tls>
    </endpoint>
</listen>

```

```
        </client-identity>
        <server-auth>
          <pinned-ca-certs>explicitly-trusted-server-ca-certs</pinne\
d-ca-certs>
          <pinned-server-certs>explicitly-trusted-server-certs</pinn\
ed-server-certs>
        </server-auth>
      </tls>
    </endpoint>
  </listen>
</restconf-client>
```

2.3. YANG Module

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

```
<CODE BEGINS> file "ietf-restconf-client@2018-10-22.yang"
module ietf-restconf-client {
  yang-version 1.1;

  namespace "urn:ietf:params:xml:ns:yang:ietf-restconf-client";
  prefix "rcc";

  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-tls-client {
    prefix ts;
    revision-date 2018-10-22; // stable grouping definitions
    reference
      "RFC ZZZZ: YANG Groupings for TLS Clients and TLS Servers";
  }

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

  contact
    "WG Web: <http://datatracker.ietf.org/wg/restconf/>
```

WG List: <mailto:restconf@ietf.org>
Author: Kent Watsen
<mailto:kwatsen@juniper.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; see the RFC itself for full legal notices.";

```
revision "2018-10-22" {
  description
    "Initial version";
  reference
    "RFC XXXX: RESTCONF Client and Server Models";
}

// Features

feature initiate {
  description
    "The 'initiate' feature indicates that the RESTCONF client
    supports initiating RESTCONF connections to RESTCONF servers
    using at least one transport (e.g., TLS, etc.).";
}

feature tls-initiate {
  if-feature initiate;
  description
    "The 'tls-initiate' feature indicates that the RESTCONF client
    supports initiating TLS connections to RESTCONF servers. This
    feature exists as TLS might not be a mandatory to implement
```

```
        transport in the future.";
    reference
        "RFC 8040: RESTCONF Protocol";
}

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

feature tls-listen {
    if-feature listen;
    description
        "The 'tls-listen' feature indicates that the RESTCONF client
        supports opening a port to listen for incoming RESTCONF
        server call-home TLS connections. This feature exists as
        TLS might not be a mandatory to implement transport in the
        future.";
    reference
        "RFC 8071: NETCONF Call Home and RESTCONF Call Home";
}

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

grouping restconf-client-grouping {
    description
        "Top-level grouping for RESTCONF client configuration.";

    container initiate {
        if-feature 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 tls {
          if-feature tls-initiate;
          container tls {
            description
              "Specifies TLS-specific transport
              configuration.";
            leaf address {
              type inet:host;
              mandatory true;
              description
                "The IP address or hostname of the endpoint.
                If a domain name is configured, then the
                DNS resolution should happen on each usage
                attempt. If the the DNS resolution results
                in multiple IP addresses, the IP addresses
                will be tried according to local preference
                order until a connection has been established
                or until all IP addresses have failed.";
            }
            leaf port {
              type inet:port-number;
              default 443;
              description
```

```
        "The IP port for this endpoint. The RESTCONF
        client will use the IANA-assigned well-known
        port for 'https' (443) if no value is
        specified.";
    }
    uses ts:tls-client-grouping {
        refine "client-identity/auth-type" {
            mandatory true;
            description
                "RESTCONF clients MUST pass some
                authentication credentials.";
        }
    }
} // end tls
} // end transport
container connection-type {
    description
        "Indicates the kind of connection to use.";
    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 it,
                    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.";
                container keep-alives {
                    description
                        "Configures the keep-alive policy, to
                        proactively test the aliveness of the TLS
                        server. An unresponsive TLS server will
                        be dropped after approximately max-attempts
                        * max-wait seconds.";
                    leaf max-wait {
                        type uint16 {
                            range "1..max";
                        }
                        units seconds;
                    }
                }
            }
        }
    }
}
```



```
        + '(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 TLS session may remain
            idle. A TLS 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.";
    }
    }
    } // end periodic-connection
} // end connection-type
} // end 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).";
}
} // end reconnect-strategy
} // end endpoint
} // end endpoints
} // end restconf-server
} // end initiate

container listen {
    if-feature 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 TLS session may remain idle. A TLS 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.";
  }
  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 tls {
      if-feature tls-listen;
      container tls {
        description
          "TLS-specific listening configuration for inbound
          connections.";
        leaf address {
          type inet:ip-address;
          description
            "The IP address to listen on for incoming call-
            home connections. The RESTCONF client will
            listen on all configured interfaces if no
            value is specified. INADDR_ANY (0.0.0.0) or
            INADDR6_ANY (0:0:0:0:0:0:0:0 a.k.a. ::) MUST
            be used when the server is to listen on all
            IPv4 or IPv6 addresses, respectively.";
        }
        leaf port {
          type inet:port-number;
          default 4336;
          description
            "The port number to listen on for call-home
```

```

        connections. The RESTCONF client will listen
        on the IANA-assigned well-known port for
        'restconf-ch-tls' (4336) if no value is
        specified.";
    }
    uses ts:tls-client-grouping {
        refine "client-identity/auth-type" {
            mandatory true;
            description
                "RESTCONF clients MUST pass some authentication
                credentials.";
        }
    }
}
} // end transport
} // end endpoint
} // end listen
} // end restconf-client
}
<CODE ENDS>

```

3. The RESTCONF Server Model

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

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

YANG feature statements are used to enable implementations to advertise which parts of the model the 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. Just the container is displayed below, but there is also a reusable grouping called "restconf-server-grouping" that the container is using.

[Note: '\ ' line wrapping for formatting only]

```

module: ietf-restconf-server
  +--rw restconf-server
     +--rw listen! {listen}?
        | +--rw endpoint* [name]

```

```

+--rw name          string
+--rw (transport)
  +--:(tls) {tls-listen}?
    +--rw tls
      +--rw address?          inet:ip-address
      +--rw port?             inet:port-number
      +--rw server-identity
        | +--rw (local-or-keystore)
        |   +--:(local) {local-keys-supported}?
        |   | +--rw algorithm?
        |   | | asymmetric-key-encryption-algor\
ithm-ref   |
        |   | +--rw public-key?          binary
        |   | +--rw private-key?        union
        |   | +---x generate-hidden-key
        |   | | +---w input
        |   | |   +---w algorithm
        |   | |   | asymmetric-key-encryption\
-algorithm-ref
        |   |
        |   | +---x install-hidden-key
        |   | | +---w input
        |   | |   +---w algorithm
        |   | |   | asymmetric-key-encryption\
-algorithm-ref
        |   |
        |   |   +---w public-key?    binary
        |   |   +---w private-key?   binary
        |   | +--rw cert?
        |   | | end-entity-cert-cms
        |   | +---n certificate-expiration
        |   | |   +-- expiration-date
        |   | |     yang:date-and-time
        |   | +--:(keystore) {keystore-supported}?
        |   | +--rw reference?
        |   |   ks:asymmetric-key-certificate-r\
ef
        |
+--rw client-auth
  +--rw pinned-ca-certs?
  |   ta:pinned-certificates-ref
  |   {ta:x509-certificates}?
  +--rw pinned-client-certs?
  |   ta:pinned-certificates-ref
  |   {ta:x509-certificates}?
  +--rw cert-maps
    +--rw cert-to-name* [id]
      +--rw id          uint32
      +--rw fingerprint
      |   x509c2n:tls-fingerprint
      +--rw map-type    identityref

```

```

|           |           +--rw name           string
|           |           +--rw hello-params
|           |           |           {tls-server-hello-params-config}?
|           |           |           +--rw tls-versions
|           |           |           |           +--rw tls-version*  identityref
|           |           |           |           +--rw cipher-suites
|           |           |           |           |           +--rw cipher-suite*  identityref
+--rw call-home! {call-home}?
  +--rw restconf-client* [name]
    +--rw name           string
    +--rw endpoints
      +--rw endpoint* [name]
        +--rw name           string
        +--rw (transport)
          +--:(tls) {tls-call-home}?
            +--rw tls
              +--rw address           inet:host
              +--rw port?             inet:port-number
              +--rw server-identity
                +--rw (local-or-keystore)
                  +--:(local) {local-keys-supported}?
                    +--rw algorithm?
                      |           asymmetric-key-encryption\
-algorithm-ref
                      |           +--rw public-key?
                      |           |           binary
                      |           +--rw private-key?
                      |           |           union
                      |           +---x generate-hidden-key
                      |           |           +---w input
                      |           |           +---w algorithm
                      |           |           |           asymmetric-key-encr\
yption-algorithm-ref
                      |           +---x install-hidden-key
                      |           |           +---w input
                      |           |           +---w algorithm
                      |           |           |           asymmetric-key-encr\
yption-algorithm-ref
                      |           |           +---w public-key?  binary
                      |           |           +---w private-key?  binary
                      |           +--rw cert?
                      |           |           end-entity-cert-cms
                      |           +---n certificate-expiration
                      |           |           +-- expiration-date
                      |           |           |           yang:date-and-time
                      |           +--:(keystore) {keystore-supported}?
                      |           +--rw reference?
                      |           |           ks:asymmetric-key-certifi\

```

```

cate-ref
|
|   +--rw client-auth
|   |   +--rw pinned-ca-certs?
|   |   |   ta:pinned-certificates-ref
|   |   |   {ta:x509-certificates}?
|   |   +--rw pinned-client-certs?
|   |   |   ta:pinned-certificates-ref
|   |   |   {ta:x509-certificates}?
|   |   +--rw cert-maps
|   |   |   +--rw cert-to-name* [id]
|   |   |   |   +--rw id          uint32
|   |   |   |   +--rw fingerprint
|   |   |   |   |   x509c2n:tls-fingerprint
|   |   |   |   +--rw map-type      identityref
|   |   |   |   +--rw name          string
|   |   +--rw hello-params
|   |   |   {tls-server-hello-params-config}?
|   |   +--rw tls-versions
|   |   |   +--rw tls-version*      identityref
|   |   +--rw cipher-suites
|   |   |   +--rw cipher-suite*     identityref
|   +--rw connection-type
|   |   +--rw (connection-type)
|   |   |   +--:(persistent-connection)
|   |   |   |   +--rw persistent!
|   |   |   |   |   +--rw keep-alives
|   |   |   |   |   |   +--rw max-wait?      uint16
|   |   |   |   |   |   +--rw max-attempts?  uint8
|   |   |   |   +--:(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

```

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 3.2 of [I-D.ietf-netconf-keystore].

[Note: '\ ' line wrapping for formatting only]

```
<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>
      <tls>
        <address>11.22.33.44</address>
        <server-identity>
          <algorithm xmlns:ct="urn:ietf:params:xml:ns:yang:ietf-cryp\
to-types">ct:rsa2048</algorithm>
          <private-key>base64encodedvalue==</private-key>
          <public-key>base64encodedvalue==</public-key>
          <cert>base64encodedvalue==</cert>
        </server-identity>
        <client-auth>
          <pinned-ca-certs>explicitly-trusted-client-ca-certs</pinne\
d-ca-certs>
          <pinned-client-certs>explicitly-trusted-client-certs</pinn\
ed-client-certs>
          <cert-maps>
            <cert-to-name>
              <id>1</id>
              <fingerprint>11:0A:05:11:00</fingerprint>
              <map-type>x509c2n:san-any</map-type>
            </cert-to-name>
            <cert-to-name>
              <id>2</id>
              <fingerprint>B3:4F:A1:8C:54</fingerprint>
              <map-type>x509c2n:specified</map-type>
              <name>scooby-doo</name>
            </cert-to-name>
          </cert-maps>
        </client-auth>
      </tls>
    </endpoint>
  </listen>

  <!-- call home to a RESTCONF client with two endpoints -->
  <call-home>
    <restconf-client>
      <name>config-manager</name>
      <endpoints>
        <endpoint>
          <name>east-data-center</name>
          <tls>
```

```

        <address>22.33.44.55</address>
        <server-identity>
          <algorithm xmlns:ct="urn:ietf:params:xml:ns:yang:ietf-\
crypto-types">ct:rsa2048</algorithm>
          <private-key>base64encodedvalue==</private-key>
          <public-key>base64encodedvalue==</public-key>
          <cert>base64encodedvalue==</cert>
        </server-identity>
        <client-auth>
          <pinned-ca-certs>explicitly-trusted-client-ca-certs</p\
inned-ca-certs>
          <pinned-client-certs>explicitly-trusted-client-certs</\
pinned-client-certs>
          <cert-maps>
            <cert-to-name>
              <id>1</id>
              <fingerprint>11:0A:05:11:00</fingerprint>
              <map-type>x509c2n:san-any</map-type>
            </cert-to-name>
            <cert-to-name>
              <id>2</id>
              <fingerprint>B3:4F:A1:8C:54</fingerprint>
              <map-type>x509c2n:specified</map-type>
              <name>scooby-doo</name>
            </cert-to-name>
          </cert-maps>
        </client-auth>
      </tls>
    </endpoint>
  </endpoint>
  <name>west-data-center</name>
  <tls>
    <address>33.44.55.66</address>
    <server-identity>
      <algorithm xmlns:ct="urn:ietf:params:xml:ns:yang:ietf-\
crypto-types">ct:rsa2048</algorithm>
      <private-key>base64encodedvalue==</private-key>
      <public-key>base64encodedvalue==</public-key>
      <cert>base64encodedvalue==</cert>
    </server-identity>
    <client-auth>
      <pinned-ca-certs>explicitly-trusted-client-ca-certs</p\
inned-ca-certs>
      <pinned-client-certs>explicitly-trusted-client-certs</\
pinned-client-certs>
      <cert-maps>
        <cert-to-name>
          <id>1</id>

```

```

        <fingerprint>11:0A:05:11:00</fingerprint>
        <map-type>x509c2n:san-any</map-type>
    </cert-to-name>
    <cert-to-name>
        <id>2</id>
        <fingerprint>B3:4F:A1:8C:54</fingerprint>
        <map-type>x509c2n:specified</map-type>
        <name>scooby-doo</name>
    </cert-to-name>
</cert-maps>
</client-auth>
</tls>
</endpoint>
</endpoints>
<connection-type>
    <periodic>
        <idle-timeout>300</idle-timeout>
        <period>60</period>
    </periodic>
</connection-type>
<reconnect-strategy>
    <start-with>last-connected</start-with>
    <max-attempts>3</max-attempts>
</reconnect-strategy>
</restconf-client>
</call-home>
</restconf-server>

```

3.3. YANG Module

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

```

<CODE BEGINS> file "ietf-restconf-server@2018-10-22.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-tls-server {
  prefix ts;
  revision-date 2018-10-22; // stable grouping definitions
  reference
    "RFC ZZZZ: YANG Groupings for TLS Clients and TLS Servers";
}

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

contact
  "WG Web: <http://datatracker.ietf.org/wg/netconf/>
  WG List: <mailto:netconf@ietf.org>

  Author: Kent Watsen
          <mailto:kwatsen@juniper.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) 2017 IETF Trust and the persons identified 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
  (http://trustee.ietf.org/license-info).
```

This version of this YANG module is part of RFC XXXX; see the RFC itself for full legal notices.";

```
revision "2018-10-22" {
  description
    "Initial version";
  reference
    "RFC XXXX: RESTCONF Client and Server Models";
}

// Features

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

feature tls-listen {
  if-feature listen;
  description
    "The 'tls-listen' feature indicates that the RESTCONF server
    supports opening a port to listen for incoming RESTCONF
    client connections. This feature exists as TLS might not
    be a mandatory to implement transport in the future.";
  reference
    "RFC 8040: RESTCONF Protocol";
}

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

feature tls-call-home {
  if-feature call-home;
  description
    "The 'tls-call-home' feature indicates that the RESTCONF
    server supports initiating connections to RESTCONF clients.
    This feature exists as TLS might not be a mandatory to
    implement transport in the future.";
```

```
reference
  "RFC 8071: NETCONF Call Home and RESTCONF Call Home";
}

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

grouping restconf-server-grouping {
  description
    "Top-level grouping for RESTCONF server configuration.";

  container listen {
    if-feature listen;
    presence "Enables server to listen for TCP 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.";
      }
    }
    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 tls {
        if-feature tls-listen;
        container tls {
          description
            "TLS-specific listening configuration for inbound
            connections.";
          leaf address {
            type inet:ip-address;
            description
              "The IP address to listen on for incoming
              connections. The RESTCONF server will listen
              on all configured interfaces if no value is
              specified. INADDR_ANY (0.0.0.0) or INADDR6_ANY
              (0:0:0:0:0:0:0:0 a.k.a. ::) MUST be used when
```

```
        the server is to listen on all IPv4 or IPv6
        addresses, respectively.";
    }
leaf port {
    type inet:port-number;
    default 443;
    description
        "The local port number to listen on.  If no value
        is specified, the IANA-assigned port value for
        'https' (443) is used.";
}
uses ts:tls-server-grouping {
    refine "client-auth" {
        must 'pinned-ca-certs or pinned-client-certs';
        description
            "RESTCONF servers MUST be able to validate
            clients.";
    }
    augment "client-auth" {
        description
            "Augments in the cert-to-name structure,
            so the RESTCONF server can map TLS-layer
            client certificates to RESTCONF usernames.";
        container cert-maps {
            uses x509c2n:cert-to-name;
            description
                "The cert-maps container is used by a TLS-
                based RESTCONF server 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.";
        }
    }
} // end tls container
} // end tls case
} // end transport
} // end endpoint
} // end listen

container call-home {
    if-feature call-home;
```

```
presence "Enables server to initiate TCP connections";
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.";
      }
    }
    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 tls {
        if-feature tls-call-home;
        container tls {
          description
            "Specifies TLS-specific call-home transport
            configuration.";
          leaf address {
            type inet:host;
            mandatory true;
            description
              "The IP address or hostname of the endpoint.
              If a domain name is configured, then the
              DNS resolution should happen on each usage";
          }
        }
      }
    }
  }
}
```

```
        attempt.  If the DNS resolution results in
        multiple IP addresses, the IP addresses will
        be tried according to local preference order
        until a connection has been established or
        until all IP addresses have failed.";
    }
    leaf port {
        type inet:port-number;
        default 4336;
        description
            "The IP port for this endpoint.  The RESTCONF
            server will use the IANA-assigned well-known
            port for 'restconf-ch-tls' (4336) if no value
            is specified.";
    }
    uses ts:tls-server-grouping {
        refine "client-auth" {
            must 'pinned-ca-certs or pinned-client-certs';
            description
                "RESTCONF servers MUST be able to validate
                clients.";
        }
        augment "client-auth" {
            description
                "Augments in the cert-to-name structure,
                so the RESTCONF server can map TLS-layer
                client certificates to RESTCONF usernames.";
            container cert-maps {
                uses x509c2n:cert-to-name;
                description
                    "The cert-maps container is used by a
                    TLS-based RESTCONF server 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.";
            }
        }
    }
} // end transport
```

```
    } // end endpoint
  } // end endpoints
  container connection-type {
    description
      "Indicates the RESTCONF client's preference for how the
      RESTCONF server's 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 it, 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.";
          container keep-alives {
            description
              "Configures the keep-alive policy, to
              proactively test the aliveness of the TLS
              client. An unresponsive TLS client will
              be dropped after approximately (max-attempts
              * max-wait) seconds.";
            reference
              "RFC 8071: NETCONF Call Home and RESTCONF
              Call Home, Section 4.1, item S7";
            leaf max-wait {
              type uint16 {
                range "1..max";
              }
              units seconds;
              default 30;
              description
                "Sets the amount of time in seconds after
                which if no data has been received from
                the TLS client, a TLS-level message will
                be sent to test the aliveness of the TLS
                client.";
            }
          }
        }
      }
    }
  }
```

```
leaf max-attempts {
  type uint8;
  default 3;
  description
    "Sets the maximum number of sequential keep-
    alive messages that can fail to obtain a
    response from the TLS client before assuming
    the TLS client is no longer alive.";
}
}
}
}
case periodic-connection {
  container periodic {
    presence
      "Indicates that a periodic connection is to be
      maintained.";
    description
      "Periodically connect to the RESTCONF client. The
      RESTCONF client should close the underlying TLS
      connection upon completing planned activities.

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


/: The entire data trees defined by the modules defined in this draft are sensitive to write operations. For instance, the addition or removal of references to keys, certificates, trusted anchors, etc., can dramatically alter the implemented security policy. However, no NACM annotations are applied as the data SHOULD be editable by users other than a designated 'recovery session'.

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

NONE

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

NONE

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:

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

URI: urn:ietf:params:xml:ns:yang:ietf-restconf-server
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 the following registrations are requested:

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

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

6. References

6.1. Normative References

- [I-D.ietf-netconf-keystore]
Watsen, K., "YANG Data Model for a Centralized Keystore Mechanism", draft-ietf-netconf-keystore-06 (work in progress), September 2018.
- [I-D.ietf-netconf-tls-client-server]
Watsen, K. and G. Wu, "YANG Groupings for TLS Clients and TLS Servers", draft-ietf-netconf-tls-client-server-07 (work in progress), September 2018.
- [RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, DOI 10.17487/RFC2119, March 1997, <<https://www.rfc-editor.org/info/rfc2119>>.
- [RFC6020] Bjorklund, M., Ed., "YANG - A Data Modeling Language for the Network Configuration Protocol (NETCONF)", RFC 6020, DOI 10.17487/RFC6020, October 2010, <<https://www.rfc-editor.org/info/rfc6020>>.
- [RFC6991] Schoenwaelder, J., Ed., "Common YANG Data Types", RFC 6991, DOI 10.17487/RFC6991, July 2013, <<https://www.rfc-editor.org/info/rfc6991>>.
- [RFC7407] Bjorklund, M. and J. Schoenwaelder, "A YANG Data Model for SNMP Configuration", RFC 7407, DOI 10.17487/RFC7407, December 2014, <<https://www.rfc-editor.org/info/rfc7407>>.
- [RFC7950] Bjorklund, M., Ed., "The YANG 1.1 Data Modeling Language", RFC 7950, DOI 10.17487/RFC7950, August 2016, <<https://www.rfc-editor.org/info/rfc7950>>.

- [RFC8040] Bierman, A., Bjorklund, M., and K. Watsen, "RESTCONF Protocol", RFC 8040, DOI 10.17487/RFC8040, January 2017, <<https://www.rfc-editor.org/info/rfc8040>>.
- [RFC8071] Watsen, K., "NETCONF Call Home and RESTCONF Call Home", RFC 8071, DOI 10.17487/RFC8071, February 2017, <<https://www.rfc-editor.org/info/rfc8071>>.
- [RFC8174] Leiba, B., "Ambiguity of Uppercase vs Lowercase in RFC 2119 Key Words", BCP 14, RFC 8174, DOI 10.17487/RFC8174, May 2017, <<https://www.rfc-editor.org/info/rfc8174>>.

6.2. Informative References

- [I-D.ietf-netconf-netconf-client-server]
Watsen, K., "NETCONF Client and Server Models", draft-ietf-netconf-netconf-client-server-07 (work in progress), September 2018.
- [RFC3688] Mealling, M., "The IETF XML Registry", BCP 81, RFC 3688, DOI 10.17487/RFC3688, January 2004, <<https://www.rfc-editor.org/info/rfc3688>>.
- [RFC6241] Enns, R., Ed., Bjorklund, M., Ed., Schoenwaelder, J., Ed., and A. Bierman, Ed., "Network Configuration Protocol (NETCONF)", RFC 6241, DOI 10.17487/RFC6241, June 2011, <<https://www.rfc-editor.org/info/rfc6241>>.
- [RFC8340] Bjorklund, M. and L. Berger, Ed., "YANG Tree Diagrams", BCP 215, RFC 8340, DOI 10.17487/RFC8340, March 2018, <<https://www.rfc-editor.org/info/rfc8340>>.
- [RFC8341] Bierman, A. and M. Bjorklund, "Network Configuration Access Control Model", STD 91, RFC 8341, DOI 10.17487/RFC8341, March 2018, <<https://www.rfc-editor.org/info/rfc8341>>.
- [RFC8446] Rescorla, E., "The Transport Layer Security (TLS) Protocol Version 1.3", RFC 8446, DOI 10.17487/RFC8446, August 2018, <<https://www.rfc-editor.org/info/rfc8446>>.

Appendix A. Change Log

A.1. 00 to 01

- o Renamed "keychain" to "keystore".

A.2. 01 to 02

- o Filled in previously missing 'ietf-restconf-client' module.
- o Updated the ietf-restconf-server module to accomodate new grouping 'ietf-tls-server-grouping'.

A.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).

A.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)

A.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)

A.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.

A.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.

A.8. 07 to 08

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

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