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RESTCONF Client and Server Models

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 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.

Artwork in this document contains shorthand references to drafts in progress. Please apply the following replacements (note: not all may be present):

- *AAAA --> the assigned RFC value for draft-ietf-netconf-crypto-types
- *BBBB --> the assigned RFC value for draft-ietf-netconf-trust-anchors
- *CCCC --> the assigned RFC value for draft-ietf-netconf-keystore
- *DDDD --> the assigned RFC value for draft-ietf-netconf-tcp-client-server
- *EEEE --> the assigned RFC value for draft-ietf-netconf-ssh-client-server
- *FFFF --> the assigned RFC value for draft-ietf-netconf-tls-client-server
- *GGGG --> the assigned RFC value for draft-ietf-netconf-http-client-server
- *HHHH --> the assigned RFC value for draft-ietf-netconf-netconf-client-server

*IIII --> the assigned RFC value for this draft

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

*2022-12-12 --> the publication date of this draft

The "Relation to other RFCs" section [Section 1.1](#) contains the text "one or more YANG modules" and, later, "modules". This text is sourced from a file in a context where it is unknown how many modules a draft defines. The text is not wrong as is, but it may be improved by stating more directly how many modules are defined.

The "Relation to other RFCs" section [Section 1.1](#) contains a self-reference to this draft, along with a corresponding Informative Reference in the Appendix.

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

*[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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This Internet-Draft will expire on 15 June 2023.

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 - [A.28. 27 to 28](#)
- [Acknowledgements](#)
- [Author's Address](#)

1. Introduction

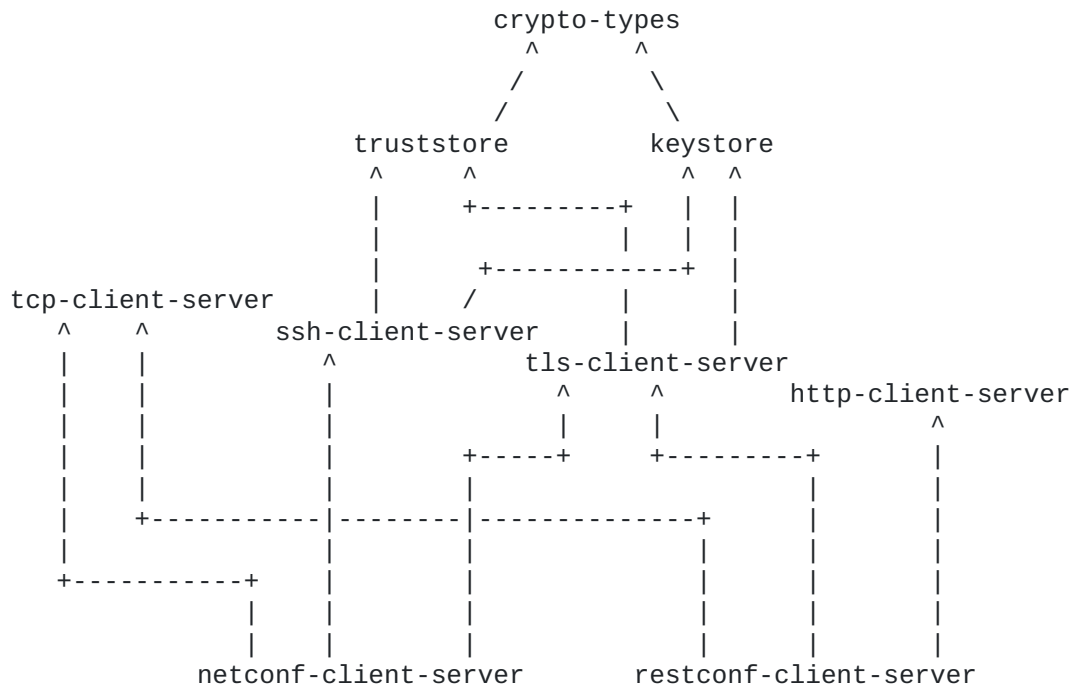
This document defines two YANG [[RFC7950](#)] modules, one module to configure a RESTCONF client and the other module to configure a RESTCONF server [[RFC8040](#)]. Both modules support the TLS [[RFC8446](#)]

transport protocol with both standard RESTCONF and RESTCONF Call Home connections [[RFC8071](#)].

1.1. Relation to other RFCs

This document presents one or more YANG modules [[RFC7950](#)] that are part of a collection of RFCs that work together to, ultimately, enable the configuration of both the clients and servers of both the NETCONF [[RFC6241](#)] and RESTCONF [[RFC8040](#)] protocols.

The normative dependency relationship between the various RFCs in this collection is presented in the below diagram. The labels in the diagram represent the primary purpose provided by each RFC. Hyperlinks to each RFC are provided below the diagram.



Label in Diagram	Originating RFC
crypto-types	[I-D.ietf-netconf-crypto-types]
truststore	[I-D.ietf-netconf-trust-anchors]
keystore	[I-D.ietf-netconf-keystore]
tcp-client-server	[I-D.ietf-netconf-tcp-client-server]
ssh-client-server	[I-D.ietf-netconf-ssh-client-server]
tls-client-server	[I-D.ietf-netconf-tls-client-server]
http-client-server	[I-D.ietf-netconf-http-client-server]
netconf-client-server	[I-D.ietf-netconf-netconf-client-server]
restconf-client-server	[I-D.ietf-netconf-restconf-client-server]

Table 1: Label to RFC Mapping

1.2. Specification Language

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "NOT RECOMMENDED", "MAY", and

"OPTIONAL" in this document are to be interpreted as described in BCP 14 [[RFC2119](#)] [[RFC8174](#)] when, and only when, they appear in all capitals, as shown here.

1.3. Adherence to the NMDA

This document is compliant with the Network Management Datastore Architecture (NMDA) [[RFC8342](#)]. For instance, as described in [[I-D.ietf-netconf-trust-anchors](#)] and [[I-D.ietf-netconf-keystore](#)], trust anchors and keys installed during manufacturing are expected to appear in <operational>.

1.4. Conventions

Various examples used in this document use a placeholder value for binary data that has been base64 encoded (e.g., "BASE64VALUE="). This placeholder value is used as real base64 encoded structures are often many lines long and hence distracting to the example being presented.

2. The "ietf-restconf-client" Module

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. Data Model Overview

This section provides an overview of the "ietf-restconf-client" module in terms of its features and groupings.

2.1.1. Features

The following diagram lists all the "feature" statements defined in the "ietf-restconf-client" module:

Features:

```
+-- https-initiate
+-- http-listen
+-- https-listen
+-- central-restconf-client-supported
```

The diagram above uses syntax that is similar to but not defined in [[RFC8340](#)].

2.1.2. Groupings

The "ietf-restconf-client" module defines the following "grouping" statements:

```
*restconf-client-grouping
*restconf-client-initiate-stack-grouping
*restconf-client-listen-stack-grouping
*restconf-client-app-grouping
```

Each of these groupings are presented in the following subsections.

2.1.2.1. The "restconf-client-grouping" Grouping

The following tree diagram [[RFC8340](#)] illustrates the "restconf-client-grouping" grouping:

```
grouping restconf-client-grouping ---> <empty>:
```

Comments:

*This grouping does not define any nodes, but is maintained so that downstream modules can augment nodes into it if needed.

*The "restconf-client-grouping" defines, if it can be called that, the configuration for just "RESTCONF" part of a protocol stack. It does not, for instance, define any configuration for the "TCP", "TLS", or "HTTP" protocol layers (for that, see [Section 2.1.2.2](#) and [Section 2.1.2.3](#)).

2.1.2.2. The "restconf-client-initiate-stack-grouping" Grouping

The following tree diagram [[RFC8340](#)] illustrates the "restconf-client-initiate-stack-grouping" grouping:

```
grouping restconf-client-initiate-stack-grouping:
+-- (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
      +-- restconf-client-parameters
        +---u rcc:restconf-client-grouping
```

Comments:

*The "restconf-client-initiate-stack-grouping" defines the configuration for a full RESTCONF protocol stack, for RESTCONF clients that initiate connections to RESTCONF servers, as opposed to receiving call-home [[RFC8071](#)] connections.

*The "transport" choice node enables transport options to be configured. This document only defines an "https" option, but other options MAY be augmented in.

*For the referenced grouping statement(s):

- The "tcp-client-grouping" grouping is discussed in [Section 3.1.2.1](#) of [[I-D.ietf-netconf-tcp-client-server](#)].
- The "tls-client-grouping" grouping is discussed in [Section 3.1.2.1](#) of [[I-D.ietf-netconf-tls-client-server](#)].
- The "http-client-grouping" grouping is discussed in [Section 2.1.2.2](#) of [[I-D.ietf-netconf-http-client-server](#)].

-The "restconf-client-grouping" grouping is discussed in [Section 2.1.2.1](#) in this document.

2.1.2.3. The "restconf-client-listen-stack-grouping" Grouping

The following tree diagram [[RFC8340](#)] illustrates the "restconf-client-listen-stack-grouping" grouping:

```
grouping restconf-client-listen-stack-grouping:
  +-- (transport)
    +--:(http) {http-listen}?
      | +-- http
      |   +-- tcp-server-parameters
      |     | +---u tcps:tcp-server-grouping
      |   +-- http-client-parameters
      |     | +---u httpc:http-client-grouping
      |   +-- restconf-client-parameters
      |     +---u rcc:restconf-client-grouping
    +--:(https) {https-listen}?
      +-- https
        +-- tcp-server-parameters
          | +---u tcps:tcp-server-grouping
        +-- tls-client-parameters
          | +---u tlsc:tls-client-grouping
        +-- http-client-parameters
          | +---u httpc:http-client-grouping
        +-- restconf-client-parameters
          +---u rcc:restconf-client-grouping
```

Comments:

*The "restconf-client-listen-stack-grouping" defines the configuration for a full RESTCONF protocol stack, for RESTCONF clients that receive call-home [[RFC8071](#)] connections from RESTCONF servers.

*The "transport" choice node enables both the HTTP and HTTPS transports to be configured, with each option enabled by a "feature" statement. Note that RESTCONF requires HTTPS, the HTTP option is provided to support cases where a TLS-terminator is deployed in front of the RESTCONF-client.

*For the referenced grouping statement(s):

- The "tcp-server-grouping" grouping is discussed in [Section 4.1.2.1](#) of [[I-D.ietf-netconf-tcp-client-server](#)].
- The "tls-client-grouping" grouping is discussed in [Section 3.1.2.1](#) of [[I-D.ietf-netconf-tls-client-server](#)].
- The "http-client-grouping" grouping is discussed in [Section 2.1.2.2](#) of [[I-D.ietf-netconf-http-client-server](#)].
- The "restconf-client-grouping" grouping is discussed in [Section 2.1.2.1](#) in this document.

2.1.2.4. The "restconf-client-app-grouping" Grouping

The following tree diagram [[RFC8340](#)] illustrates the "restconf-client-app-grouping" grouping:

```

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

```

Comments:

*The "restconf-client-app-grouping" defines the configuration for a RESTCONF client that supports both initiating connections to RESTCONF servers as well as receiving call-home connections from RESTCONF servers.

*Both the "initiate" and "listen" subtrees must be enabled by "feature" statements.

*For the referenced grouping statement(s):

-The "restconf-client-initiate-stack-grouping" grouping is discussed in [Section 2.1.2.2](#) in this document.

-The "restconf-client-listen-stack-grouping" grouping is discussed in [Section 2.1.2.3](#) in this document.

2.1.3. Protocol-accessible Nodes

The following tree diagram [[RFC8340](#)] lists all the protocol-accessible nodes defined in the "ietf-restconf-client" module:

```

module: ietf-restconf-client
+--rw restconf-client {central-restconf-client-supported}?
    +---u restconf-client-app-grouping

```

Comments:

*Protocol-accessible nodes are those nodes that are accessible when the module is "implemented", as described in [Section 5.6.5](#) of [[RFC7950](#)].

*The top-level node "restconf-client" is additionally constrained by the feature "central-restconf-client-supported".

*The "restconf-client-app-grouping" grouping is discussed in [Section 2.1.2.4](#) in this document.

*The reason for why "restconf-client-app-grouping" exists separate from the protocol-accessible nodes definition is so as to enable instances of restconf-client-app-grouping to be instantiated in other locations, as may be needed or desired by some modules.

2.2. Example Usage

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

This example is consistent with the examples presented in [Section 2.2](#) of [[I-D.ietf-netconf-trust-anchors](#)] and [Section 2.2](#) of [[I-D.ietf-netconf-keystore](#)].

===== NOTE: '\ ' line wrapping per RFC 8792 =====

```
<restconf-client xmlns="urn:ietf:params:xml:ns:yang:ietf-restconf-cl\
ient">
```

```
<!-- 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>
```

```
<certificate>
```

```
<keystore-reference>
```

```
<asymmetric-key>rsa-asymmetric-key</asymmetric-k\
```

```
ey>
```

```
<certificate>ex-rsa-cert</certificate>
```

```
</keystore-reference>
```

```
</certificate>
```

```
</client-identity>
```

```
<server-authentication>
```

```
<ca-certs>
```

```
<truststore-reference>trusted-server-ca-certs</tru\
```

```
ststore-reference>
```

```
</ca-certs>
```

```
<ee-certs>
```

```
<truststore-reference>trusted-server-ee-certs</tru\
```

```
ststore-reference>
```

```
</ee-certs>
```

```
</server-authentication>
```

```
<keepalives>
```

```
<test-peer-aliveness>
```

```
<max-wait>30</max-wait>
```

```
<max-attempts>3</max-attempts>
```

```
</test-peer-aliveness>
```

```
</keepalives>
```

```
</tls-client-parameters>
```

```
<http-client-parameters>
```

```
<client-identity>
```

```
<basic>
```

```
<user-id>bob</user-id>
```

```
<cleartext-password>secret</cleartext-password>
```

```
</basic>
```

```
</client-identity>
```

```
</http-client-parameters>
```

```
</https>
```

```
</endpoint>
```

```

<endpoint>
  <name>corp-fw2.example.com</name>
  <https>
    <tcp-client-parameters>
      <remote-address>corp-fw2.example.com</remote-address>
      <keepalives>
        <idle-time>15</idle-time>
        <max-probes>3</max-probes>
        <probe-interval>30</probe-interval>
      </keepalives>
    </tcp-client-parameters>
    <tls-client-parameters>
      <client-identity>
        <certificate>
          <keystore-reference>
            <asymmetric-key>rsa-asymmetric-key</asymmetric-k\
ey>
            <certificate>ex-rsa-cert</certificate>
          </keystore-reference>
        </certificate>
      </client-identity>
      <server-authentication>
        <ca-certs>
          <truststore-reference>trusted-server-ca-certs</tru\
ststore-reference>
        </ca-certs>
        <ee-certs>
          <truststore-reference>trusted-server-ee-certs</tru\
ststore-reference>
        </ee-certs>
      </server-authentication>
    </keepalives>
    <test-peer-aliveness>
      <max-wait>30</max-wait>
      <max-attempts>3</max-attempts>
    </test-peer-aliveness>
  </keepalives>
</tls-client-parameters>
<http-client-parameters>
  <client-identity>
    <basic>
      <user-id>bob</user-id>
      <cleartext-password>secret</cleartext-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>
  <endpoint>

```

```

<name>Intranet-facing listener</name>
<https>
  <tcp-server-parameters>
    <local-address>11.22.33.44</local-address>
  </tcp-server-parameters>
  <tls-client-parameters>
    <client-identity>
      <certificate>
        <keystore-reference>
          <asymmetric-key>rsa-asymmetric-key</asymmetric-key>
          <certificate>ex-rsa-cert</certificate>
        </keystore-reference>
      </certificate>
    </client-identity>
    <server-authentication>
      <ca-certs>
        <truststore-reference>trusted-server-ca-certs</truststore-reference>
      </ca-certs>
      <ee-certs>
        <truststore-reference>trusted-server-ee-certs</truststore-reference>
      </ee-certs>
    </server-authentication>
    <keepalives>
      <peer-allowed-to-send/>
    </keepalives>
  </tls-client-parameters>
  <http-client-parameters>
    <client-identity>
      <basic>
        <user-id>bob</user-id>
        <cleartext-password>secret</cleartext-password>
      </basic>
    </client-identity>
  </http-client-parameters>
</https>
</endpoint>
</listen>
</restconf-client>

```

2.3. YANG Module

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

```
<CODE BEGINS> file "ietf-restconf-client@2022-12-12.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-tcp-client {
    prefix tcpc;
    reference
      "RFC DDDD: YANG Groupings for TCP Clients and TCP Servers";
  }

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

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

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

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

  contact
    "WG Web:  https://datatracker.ietf.org/wg/netconf
    WG List:  NETCONF WG list <mailto:netconf@ietf.org>
    Author:   Kent Watsen <mailto:kent+ietf@watsen.net>";

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

    Copyright (c) 2022 IETF Trust and the persons identified
    as authors of the code. All rights reserved.

    Redistribution and use in source and binary forms, with
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    BSD License set forth in Section 4.c of the IETF Trust's
    Legal Provisions Relating to IETF Documents
    (https://trustee.ietf.org/license-info)."

  This version of this YANG module is part of RFC IIII
```

(<https://www.rfc-editor.org/info/rfcIIII>); 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 2022-12-12 {
  description
    "Initial version";
  reference
    "RFC IIII: RESTCONF Client and Server Models";
}

// Features

feature https-initiate {
  description
    "The 'https-initiate' feature indicates that the RESTCONF
    client supports initiating HTTPS connections to RESTCONF
    servers. This feature exists as HTTPS might not be a
    mandatory to implement transport in the future.";
  reference
    "RFC 8040: RESTCONF Protocol";
}

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

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

feature central-restconf-client-supported {
  description
    "The 'central-restconf-client-supported' feature indicates
    that the server that implements this module supports
    the top-level 'restconf-client' node.

    This feature is needed as some servers may want to use
    features defined in this module, which requires this
    module to be implemented, without having to support
```

```

    the top-level 'restconf-client' node.";
}

// Groupings

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

    This grouping currently does not define any nodes. It
    exists only so the model can be consistent with other
    'client-server' models.";
}

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

  choice transport {
    mandatory true;
    description
      "Selects between available transports. This is a
      'choice' statement so as to support additional
      transport options to be augmented in.";
    case https {
      if-feature "https-initiate";
      container https {
        must 'tls-client-parameters/client-identity
          or http-client-parameters/client-identity';
        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 {
    description
      "A wrapper around the TLS client parameters
      to avoid name collisions.";
    uses tlsc:tls-client-grouping;
  }
  container http-client-parameters {
    description

```



```

        "A wrapper around the HTTP client parameters
        to avoid name collisions.";
    uses httpc:http-client-grouping;
}
container restconf-client-parameters {
    description
        "A wrapper around the RESTCONF client parameters
        to avoid name collisions.

        This container does not define any nodes. It
        exists as a potential augmentation target by
        other modules.";
    uses rcc:restconf-client-grouping;
}
}
}
} // restconf-client-initiate-stack-grouping

grouping restconf-client-listen-stack-grouping {
    description
        "A reusable grouping for configuring a RESTCONF client
        'listen' protocol stack for a single connection. The
        'listen' stack supports call home connections, as
        described in RFC 8071";
    reference
        "RFC 8071: NETCONF Call Home and RESTCONF Call Home";
    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
                    "HTTP-specific listening configuration for inbound
                    connections.

                    This transport option is made available to support
                    deployments where the TLS connections are terminated
                    by another system (e.g., a load balancer) fronting
                    the client.";
                container tcp-server-parameters {
                    description
                        "A wrapper around the TCP client parameters
                        to avoid name collisions.";
                    uses tcps:tcp-server-grouping {
                        refine "local-port" {
                            default "4336";
                            description
                                "The RESTCONF client will listen on the IANA-
                                assigned well-known port for 'restconf-ch-tls'
                                (4336) if no value is specified.";
                        }
                    }
                }
            }
        }
    }
}

```

```

container http-client-parameters {
    description
        "A wrapper around the HTTP client parameters
        to avoid name collisions.";
    uses httpc:http-client-grouping;
}
container restconf-client-parameters {
    description
        "A wrapper around the RESTCONF client parameters
        to avoid name collisions.

        This container does not define any nodes. It
        exists as a potential augmentation target by
        other modules.";
    uses rcc:restconf-client-grouping;
}
}
}
case https {
    if-feature "https-listen";
    container https {
        must 'tls-client-parameters/client-identity
            or http-client-parameters/client-identity';
        description
            "HTTPS-specific listening configuration for inbound
            connections.";
        container tcp-server-parameters {
            description
                "A wrapper around the TCP client parameters
                to avoid name collisions.";
            uses tcps:tcp-server-grouping {
                refine "local-port" {
                    default "4336";
                    description
                        "The RESTCONF client will listen on the IANA-
                        assigned well-known port for 'restconf-ch-tls'
                        (4336) if no value is specified.";
                }
            }
        }
    }
}
container tls-client-parameters {
    description
        "A wrapper around the TLS client parameters
        to avoid name collisions.";
    uses tlsc:tls-client-grouping;
}
container http-client-parameters {
    description
        "A wrapper around the HTTP client parameters
        to avoid name collisions.";
    uses httpc:http-client-grouping;
}
container restconf-client-parameters {
    description
        "A wrapper around the RESTCONF client parameters
        to avoid name collisions.

        This container does not define any nodes. It

```

```

        exists as a potential augmentation target by
        other modules.";
    uses rcc:restconf-client-grouping;
    }
}
}
} // restconf-client-listen-stack-grouping

grouping restconf-client-app-grouping {
    description
        "A reusable grouping for configuring a RESTCONF client
        application that supports both 'initiate' and 'listen'
        protocol stacks for a multiplicity of connections.";
    container initiate {
        if-feature "https-initiate";
        presence
            "Indicates that client-initiated connections have been
            configured. This statement is present so the mandatory
            descendant nodes do not imply that this node must be
            configured.";
        description
            "Configures client initiating underlying TCP connections.";
        list restconf-server {
            key "name";
            min-elements 1;
            description
                "List of RESTCONF servers the RESTCONF client is to
                maintain simultaneous connections with.";
            leaf name {
                type string;
                description
                    "An arbitrary name for the RESTCONF server.";
            }
        }
        container endpoints {
            description
                "Container for the list of endpoints.";
            list endpoint {
                key "name";
                min-elements 1;
                ordered-by user;
                description
                    "A non-empty user-ordered list of endpoints for this
                    RESTCONF client to try to connect to in sequence.
                    Defining more than one enables high-availability.";
                leaf name {
                    type string;
                    description
                        "An arbitrary name for this endpoint.";
                }
            }
            uses restconf-client-initiate-stack-grouping;
        }
    }
    container connection-type {
        description
            "Indicates the RESTCONF client's preference for how
            the RESTCONF connection is maintained.";
        choice connection-type {

```

```

mandatory true;
description
  "Selects between available connection types.";
case persistent-connection {
  container persistent {
    presence
      "Indicates that a persistent connection is to be
      maintained.";
    description
      "Maintain a persistent connection to the
      RESTCONF server. If the connection goes down,
      immediately start trying to reconnect to the
      RESTCONF server, using the reconnection strategy.

      This connection type minimizes any RESTCONF server
      to RESTCONF client data-transfer delay, albeit
      at the expense of holding resources longer.";
  }
}
case periodic-connection {
  container periodic {
    presence
      "Indicates that a periodic connection is to be
      maintained.";
    description
      "Periodically connect to the RESTCONF server.

      This connection type decreases 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-wait {
        type uint16 {
            range "1..max";
        }
        units "seconds";
        default "5";
        description
            "Specifies the amount of time in seconds after which,
            if the connection is not established, an endpoint
            connection attempt is considered unsuccessful.";
    }
    leaf max-attempts {
        type uint8 {
            range "1..max";
        }
        default "3";
        description
            "Specifies the number times the RESTCONF client
            tries to connect to a specific endpoint before
            moving on to the next endpoint in the list
            (round robin).";
    }
}
}
} // initiate
container listen {
    if-feature "http-listen or https-listen";
    presence
        "Indicates that client-listening ports have been configured.
        This statement is present so the mandatory descendant nodes
        do not imply that this node must be configured.";
    description
        "Configures the client to accept call-home TCP connections.";
    leaf idle-timeout {
        type uint16;
        units "seconds";
        default "3600"; // one hour
        description
            "Specifies the maximum number of seconds that an
            underlying TCP session may remain idle. A TCP session
            will be dropped if it is idle for an interval longer
            than this number of seconds. If set to zero, then
            the server will never drop a session because it is
            idle. Sessions that have a notification subscription
            active are never dropped.";
    }
}
list endpoint {
    key "name";
    min-elements 1;
    description
        "List of endpoints to listen for RESTCONF connections.";
    leaf name {
        type string;
        description

```

```
        "An arbitrary name for the RESTCONF listen endpoint.";
    }
    uses restconf-client-listen-stack-grouping;
}
} // restconf-client-app-grouping

// Protocol accessible node for servers that implement this module.
container restconf-client {
    if-feature central-restconf-client-supported;
    uses restconf-client-app-grouping;
    description
        "Top-level container for RESTCONF client configuration.";
}
}
```

<CODE ENDS>

3. The "ietf-restconf-server" Module

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. Data Model Overview

This section provides an overview of the "ietf-restconf-server" module in terms of its features and groupings.

3.1.1. Features

The following diagram lists all the "feature" statements defined in the "ietf-restconf-server" module:

Features:

```
+-- http-listen
+-- https-listen
+-- https-call-home
+-- central-restconf-server-supported
```

The diagram above uses syntax that is similar to but not defined in [[RFC8340](#)].

3.1.2. Groupings

The "ietf-restconf-server" module defines the following "grouping" statements:

```
*restconf-server-grouping
*restconf-server-listen-stack-grouping
*restconf-server-callhome-stack-grouping
*restconf-server-app-grouping
```

Each of these groupings are presented in the following subsections.

3.1.2.1. The "restconf-server-grouping" Grouping

The following tree diagram [[RFC8340](#)] illustrates the "restconf-server-grouping" grouping:

```
grouping restconf-server-grouping:
  +-- client-identity-mappings
     +---u x509c2n:cert-to-name
```

Comments:

*The "restconf-server-grouping" defines the configuration for just "RESTCONF" part of a protocol stack. It does not, for instance, define any configuration for the "TCP", "TLS", or "HTTP" protocol layers (for that, see [Section 3.1.2.2](#) and [Section 3.1.2.3](#)).

*The "client-identity-mappings" node, which must be enabled by "feature" statements, defines a mapping from certificate fields to RESTCONF user names.

*For the referenced grouping statement(s):

-The "cert-to-name" grouping is discussed in [Section 4.1](#) of [\[RFC7407\]](#).

3.1.2.2. The "restconf-server-listen-stack-grouping" Grouping

The following tree diagram [\[RFC8340\]](#) illustrates the "restconf-server-listen-stack-grouping" grouping:

```
grouping restconf-server-listen-stack-grouping:
+-- (transport)
  +--:(http) {http-listen}?
    | +-- http
    |   +-- external-endpoint!
    |     | +-- address      inet:ip-address
    |     | +-- port?       inet:port-number
    |     +-- tcp-server-parameters
    |         | +---u tcps:tcp-server-grouping
    |     +-- http-server-parameters
    |         | +---u https:http-server-grouping
    |     +-- restconf-server-parameters
    |         +---u rcs:restconf-server-grouping
  +--:(https) {https-listen}?
    +-- https
      +-- tcp-server-parameters
      | +---u tcps:tcp-server-grouping
      +-- tls-server-parameters
      | +---u tlss:tls-server-grouping
      +-- http-server-parameters
      | +---u https:http-server-grouping
      +-- restconf-server-parameters
          +---u rcs:restconf-server-grouping
```

Comments:

*The "restconf-server-listen-stack-grouping" defines the configuration for a full RESTCONF protocol stack for RESTCONF servers that listen for standard connections from RESTCONF clients, as opposed to initiating call-home [\[RFC8071\]](#) connections.

*The "transport" choice node enables both the HTTP and HTTPS transports to be configured, with each option enabled by a "feature" statement. The HTTP option is provided to support cases where a TLS-terminator is deployed in front of the RESTCONF-server.

*For the referenced grouping statement(s):

-The "tcp-server-grouping" grouping is discussed in [Section 4.1.2.1](#) of [\[I-D.ietf-netconf-tcp-client-server\]](#).
-The "tls-server-grouping" grouping is discussed in [Section 4.1.2.1](#) of [\[I-D.ietf-netconf-tls-client-server\]](#).

- The "http-server-grouping" grouping is discussed in [Section 3.1.2.1](#) of [[I-D.ietf-netconf-http-client-server](#)].
- The "restconf-server-grouping" is discussed in [Section 3.1.2.1](#) of this document.

3.1.2.3. The "restconf-server-callhome-stack-grouping" Grouping

The following tree diagram [[RFC8340](#)] illustrates the "restconf-server-callhome-stack-grouping" grouping:

```
grouping restconf-server-callhome-stack-grouping:
  +-- (transport)
    +--:(https) {https-listen}?
      +-- https
        +-- tcp-client-parameters
          | +---u tpc:tcp-client-grouping
        +-- tls-server-parameters
          | +---u tlss:tls-server-grouping
        +-- http-server-parameters
          | +---u https:http-server-grouping
        +-- restconf-server-parameters
          +---u rcs:restconf-server-grouping
```

Comments:

*The "restconf-server-callhome-stack-grouping" defines the configuration for a full RESTCONF protocol stack, for RESTCONF servers that initiate call-home [[RFC8071](#)] connections to RESTCONF clients.

*The "transport" choice node enables transport options to be configured. This document only defines an "https" option, but other options MAY be augmented in.

*For the referenced grouping statement(s):

- The "tcp-client-grouping" grouping is discussed in [Section 3.1.2.1](#) of [[I-D.ietf-netconf-tcp-client-server](#)].
- The "tls-server-grouping" grouping is discussed in [Section 4.1.2.1](#) of [[I-D.ietf-netconf-tls-client-server](#)].
- The "http-server-grouping" grouping is discussed in [Section 3.1.2.1](#) of [[I-D.ietf-netconf-http-client-server](#)].
- The "restconf-server-grouping" is discussed in [Section 3.1.2.1](#) of this document.

3.1.2.4. The "restconf-server-app-grouping" Grouping

The following tree diagram [[RFC8340](#)] illustrates the "restconf-server-app-grouping" grouping:

```

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

```

Comments:

*The "restconf-server-app-grouping" defines the configuration for a RESTCONF server that supports both listening for connections from RESTCONF clients as well as initiating call-home connections to RESTCONF clients.

*Both the "listen" and "call-home" subtrees must be enabled by "feature" statements.

*For the referenced grouping statement(s):

- The "restconf-server-listen-stack-grouping" grouping is discussed in [Section 3.1.2.2](#) in this document.
- The "restconf-server-callhome-stack-grouping" grouping is discussed in [Section 3.1.2.3](#) in this document.

3.1.3. Protocol-accessible Nodes

The following tree diagram [[RFC8340](#)] lists all the protocol-accessible nodes defined in the "ietf-restconf-server" module:

```

module: ietf-restconf-server
+--rw restconf-server {central-restconf-server-supported}?
    +---u restconf-server-app-grouping

```

Comments:

*Protocol-accessible nodes are those nodes that are accessible when the module is "implemented", as described in [Section 5.6.5](#) of [[RFC7950](#)].

*The top-level node "restconf-server" is additionally constrained by the feature "central-restconf-server-supported".

*The "restconf-server-app-grouping" grouping is discussed in [Section 3.1.2.4](#) in this document.

*The reason for why "restconf-server-app-grouping" exists separate from the protocol-accessible nodes definition is so as to enable instances of restconf-server-app-grouping to be instantiated in other locations, as may be needed or desired by some modules.

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 2.2](#) of [[I-D.ietf-netconf-trust-anchors](#)] and [Section 2.2](#) of [[I-D.ietf-netconf-keystore](#)].

===== NOTE: '\ ' line wrapping per RFC 8792 =====

```
<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>restconf/https</name>
      <https>
        <tcp-server-parameters>
          <local-address>11.22.33.44</local-address>
        </tcp-server-parameters>
        <tls-server-parameters>
          <server-identity>
            <certificate>
              <keystore-reference>
                <asymmetric-key>rsa-asymmetric-key</asymmetric-key>
                <certificate>ex-rsa-cert</certificate>
              </keystore-reference>
            </certificate>
          </server-identity>
          <client-authentication>
            <ca-certs>
              <truststore-reference>trusted-client-ca-certs</truststore-reference>
            </ca-certs>
            <ee-certs>
              <truststore-reference>trusted-client-ee-certs</truststore-reference>
            </ee-certs>
          </client-authentication>
          <keepalives>
            <peer-allowed-to-send/>
          </keepalives>
        </tls-server-parameters>
        <http-server-parameters>
          <server-name>foo.example.com</server-name>
        </http-server-parameters>
        <restconf-server-parameters>
          <client-identity-mappings>
            <cert-to-name>
              <id>1</id>
              <fingerprint>11:0A:05:11:00</fingerprint>
              <map-type>x509c2n:specified</map-type>
              <name>scooby-doo</name>
            </cert-to-name>
            <cert-to-name>
              <id>2</id>
              <map-type>x509c2n:san-any</map-type>
            </cert-to-name>
          </client-identity-mappings>
        </restconf-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>
            <keepalives>
              <idle-time>15</idle-time>
              <max-probes>3</max-probes>
              <probe-interval>30</probe-interval>
            </keepalives>
          </tcp-client-parameters>
          <tls-server-parameters>
            <server-identity>
              <certificate>
                <keystore-reference>
                  <asymmetric-key>rsa-asymmetric-key</asymmetric-k\
ey>
                  <certificate>ex-rsa-cert</certificate>
                </keystore-reference>
              </certificate>
            </server-identity>
            <client-authentication>
              <ca-certs>
                <truststore-reference>trusted-client-ca-certs</tru\
ststore-reference>
              </ca-certs>
              <ee-certs>
                <truststore-reference>trusted-client-ee-certs</tru\
ststore-reference>
              </ee-certs>
            </client-authentication>
          </tls-server-parameters>
          <http-server-parameters>
            <server-name>foo.example.com</server-name>
          </http-server-parameters>
          <restconf-server-parameters>
            <client-identity-mappings>
              <cert-to-name>
                <id>1</id>
                <fingerprint>11:0A:05:11:00</fingerprint>
                <map-type>x509c2n:specified</map-type>
                <name>scooby-doo</name>
              </cert-to-name>
              <cert-to-name>
                <id>2</id>
                <map-type>x509c2n:san-any</map-type>
              </cert-to-name>
            </client-identity-mappings>
          </restconf-server-parameters>
        </https>
      </endpoint>
    </endpoints>
  </restconf-client>
</call-home>

```

```

        </client-identity-mappings>
    </restconf-server-parameters>
</https>
</endpoint>
<endpoint>
    <name>west-data-center</name>
    <https>
        <tcp-client-parameters>
            <remote-address>west.example.com</remote-address>
            <keepalives>
                <idle-time>15</idle-time>
                <max-probes>3</max-probes>
                <probe-interval>30</probe-interval>
            </keepalives>
        </tcp-client-parameters>
        <tls-server-parameters>
            <server-identity>
                <certificate>
                    <keystore-reference>
                        <asymmetric-key>rsa-asymmetric-key</asymmetric-k\
ey>
                    <certificate>ex-rsa-cert</certificate>
                    </keystore-reference>
                </certificate>
            </server-identity>
            <client-authentication>
                <ca-certs>
                    <truststore-reference>trusted-client-ca-certs</tru\
ststore-reference>
                </ca-certs>
                <ee-certs>
                    <truststore-reference>trusted-client-ee-certs</tru\
ststore-reference>
                </ee-certs>
            </client-authentication>
            <keepalives>
                <test-peer-aliveness>
                    <max-wait>30</max-wait>
                    <max-attempts>3</max-attempts>
                </test-peer-aliveness>
            </keepalives>
        </tls-server-parameters>
        <http-server-parameters>
            <server-name>foo.example.com</server-name>
        </http-server-parameters>
        <restconf-server-parameters>
            <client-identity-mappings>
                <cert-to-name>
                    <id>1</id>
                    <fingerprint>11:0A:05:11:00</fingerprint>
                    <map-type>x509c2n:specified</map-type>
                    <name>scooby-doo</name>
                </cert-to-name>
                <cert-to-name>
                    <id>2</id>
                    <map-type>x509c2n:san-any</map-type>
                </cert-to-name>
            </client-identity-mappings>

```

```
        </restconf-server-parameters>
    </https>
</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-wait>3</max-wait>
    <max-attempts>3</max-attempts>
</reconnect-strategy>
</restconf-client>
</call-home>
</restconf-server>
```


3.3. YANG Module

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

```
<CODE BEGINS> file "ietf-restconf-server@2022-12-12.yang"
```

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

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

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

  import ietf-x509-cert-to-name {
    prefix x509c2n;
    reference
      "RFC 7407: A YANG Data Model for SNMP Configuration";
  }

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

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

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

  import ietf-http-server {
    prefix https;
    reference
      "RFC GGGG: YANG Groupings for HTTP Clients and HTTP Servers";
  }

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

  contact
    "WG Web:  https://datatracker.ietf.org/wg/netconf
    WG List:  NETCONF WG list <mailto:netconf@ietf.org>
    Author:   Kent Watsen <mailto:kent+ietf@watsen.net>";

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

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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 Revised BSD License set forth in Section 4.c of the IETF Trust's Legal Provisions Relating to IETF Documents (<https://trustee.ietf.org/license-info>).

This version of this YANG module is part of RFC IIII (<https://www.rfc-editor.org/info/rfcIIIII>); 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 2022-12-12 {
  description
    "Initial version";
  reference
    "RFC IIII: 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
    TPC 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";
}
```

```

feature central-restconf-server-supported {
  description
    "The 'central-restconf-server-supported' feature indicates
    that the server supports the top-level 'restconf-server'
    node.

    This feature is needed as some servers may want to use
    features defined in this module, which requires this
    module to be implemented, without having to support
    the top-level 'restconf-server' node.";
}

// Groupings

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

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

  container client-identity-mappings {
    description
      "Specifies mappings through which RESTCONF client X.509
      certificates are used to determine 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.";
    uses x509c2n:cert-to-name {
      refine "cert-to-name/fingerprint" {
        mandatory false;
        description
          "A 'fingerprint' value does not need to be specified
          when the 'cert-to-name' mapping is independent of
          fingerprint matching. A 'cert-to-name' having no
          fingerprint value will match any client certificate
          and therefore should only be present at the end of
          the user-ordered 'cert-to-name' list.";
      }
    }
  }
}

grouping restconf-server-listen-stack-grouping {
  description
    "A reusable grouping for configuring a RESTCONF server
    'listen' protocol stack for a single connection.";
}

```

```

choice transport {
  mandatory true;
  description
    "Selects between available transports. This is a
    'choice' statement so as to support additional
    transport options to be augmented in.";
  case http {
    if-feature "http-listen";
    container http {
      description
        "Configures RESTCONF server stack assuming that
        TLS-termination is handled externally.";
      container external-endpoint {
        presence
          "Identifies that an external endpoint has been
          configured. This statement is present so the
          mandatory descendant nodes do not imply that
          this node must be configured.";
        description
          "Identifies contact information for the external
          system that terminates connections before passing
          them thru to this server (e.g., a network address
          translator or a load balancer). These values have
          no effect on the local operation of this server,
          but may be used by the application when needing to
          inform other systems how to contact this server.";
        leaf address {
          type inet:ip-address;
          mandatory true;
          description
            "The IP address or hostname of the external system
            that terminates incoming RESTCONF client
            connections before forwarding them to this
            server.";
        }
        leaf port {
          type inet:port-number;
          default "443";
          description
            "The port number that the external system listens
            on for incoming RESTCONF client connections that
            are forwarded to this server. The default HTTPS
            port (443) is used, as expected for a RESTCONF
            connection.";
        }
      }
    }
  }
  container tcp-server-parameters {
    description
      "A wrapper around the TCP server parameters
      to avoid name collisions.";
    uses tcps:tcp-server-grouping {
      refine "local-port" {
        default "80";
        description
          "The RESTCONF server will listen on the IANA-
          assigned well-known port value for 'http'
          (80) if no value is specified.";
      }
    }
  }
}

```



```

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 tcp: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 for a multiplicity of connections.";
container listen {
  if-feature "http-listen or https-listen";
  presence
    "Identifies that the server has been configured to
    listen for incoming client connections. This statement
    is present so the mandatory descendant nodes do not
    imply that this node must be configured.";
  description
    "Configures the RESTCONF server to listen for RESTCONF
    client connections.";
  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
    "Identifies that the server has been configured to initiate
    call home connections. This statement is present so the
    mandatory descendant nodes do not imply that this node
    must be configured.";
  description
    "Configures the RESTCONF server to initiate the underlying
    transport connection to RESTCONF clients.";
  list restconf-client {
    key "name";
    min-elements 1;
    description
      "List of RESTCONF clients the RESTCONF server is to
      maintain simultaneous call-home connections with.";
    leaf name {
      type string;
      description
        "An arbitrary name for the remote RESTCONF client.";
    }
  }
  container endpoints {
    description
      "Container for the list of endpoints.";
    list endpoint {
      key "name";
      min-elements 1;
      ordered-by user;
      description
        "User-ordered list of endpoints for this RESTCONF
        client. Defining more than one enables high-
        availability.";
      leaf name {

```



```

        type string;
        description
            "An arbitrary name for this endpoint.";
    }
    uses restconf-server-callhome-stack-grouping;
}
}
container connection-type {
    description
        "Indicates the RESTCONF server's preference for how the
        RESTCONF connection is maintained.";
    choice connection-type {
        mandatory true;
        description
            "Selects between available connection types.";
        case persistent-connection {
            container persistent {
                presence
                    "Indicates that a persistent connection is to be
                    maintained.";
                description
                    "Maintain a persistent connection to the RESTCONF
                    client. If the connection goes down, immediately
                    start trying to reconnect to the RESTCONF client,
                    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 decreases 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;
    }
}

```



```

        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-wait {
    type uint16 {
        range "1..max";
    }
    units "seconds";
    default "5";
    description
        "Specifies the amount of time in seconds after which,
        if the connection is not established, an endpoint
        connection attempt is considered unsuccessful.";
}
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 {
    if-feature central-restconf-server-supported;
    uses restconf-server-app-grouping;
    description
        "Top-level container for RESTCONF server configuration.";
}
}

```

<CODE ENDS>

4. Security Considerations

4.1. The "ietf-restconf-client" YANG Module

The "ietf-restconf-client" YANG module defines data nodes that 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 Network 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.

None of the readable data nodes in this YANG module are considered sensitive or vulnerable in network environments. The NACM "default-deny-all" extension has not been set for any data nodes defined in this module.

None of the writable data nodes in this YANG module are considered sensitive or vulnerable in network environments. The NACM "default-deny-write" extension has not been set for any data nodes defined in this module.

This module does not define any RPCs, actions, or notifications, and thus the security consideration for such is not provided here.

Please be aware that this module uses groupings defined in other RFCs that define data nodes that do set the NACM "default-deny-all" and "default-deny-write" extensions.

4.2. The "ietf-restconf-server" YANG Module

The "ietf-restconf-server" YANG module defines data nodes that 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 Network 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.

None of the readable data nodes in this YANG module are considered sensitive or vulnerable in network environments. The NACM "default-deny-all" extension has not been set for any data nodes defined in this module.

None of the writable data nodes in this YANG module are considered sensitive or vulnerable in network environments. The NACM "default-deny-write" extension has not been set for any data nodes defined in this module.

This module does not define any RPCs, actions, or notifications, and thus the security consideration for such is not provided here.

Please be aware that this module uses groupings defined in other RFCs that define data nodes that do set the NACM "default-deny-all" and "default-deny-write" extensions.

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 IESG
XML: N/A, the requested URI is an XML namespace.

URI: urn:ietf:params:xml:ns:yang:ietf-restconf-server
Registrant Contact: The IESG
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
namespace: urn:ietf:params:xml:ns:yang:ietf-restconf-client
prefix: rcc
reference: RFC IIII

name: ietf-restconf-server
namespace: urn:ietf:params:xml:ns:yang:ietf-restconf-server
prefix: rcs
reference: RFC IIII

6. References

6.1. Normative References

[**I-D.ietf-netconf-http-client-server**] Watsen, K., "YANG Groupings for HTTP Clients and HTTP Servers", Work in Progress, Internet-Draft, draft-ietf-netconf-http-client-server-11, 19 October 2022, <<https://www.ietf.org/archive/id/draft-ietf-netconf-http-client-server-11.txt>>.

[**I-D.ietf-netconf-keystore**] Watsen, K., "A YANG Data Model for a Keystore", Work in Progress, Internet-Draft, draft-ietf-netconf-keystore-26, 19 October 2022, <<https://datatracker.ietf.org/doc/html/draft-ietf-netconf-keystore-26>>.

[**I-D.ietf-netconf-tcp-client-server**] Watsen, K. and M. Scharf, "YANG Groupings for TCP Clients and TCP Servers", Work in Progress, Internet-Draft, draft-ietf-netconf-tcp-client-server-14, 19 October 2022, <<https://>>.

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

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[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>>.

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[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-crypto-types]

Watsen, K., "YANG Data Types and Groupings for Cryptography", Work in Progress, Internet-Draft, draft-ietf-netconf-crypto-types-25, 19 October 2022, <<https://www.ietf.org/archive/id/draft-ietf-netconf-crypto-types-25.txt>>.

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

Watsen, K., "NETCONF Client and Server Models", Work in Progress, Internet-Draft, draft-ietf-netconf-netconf-client-server-27, 19 October 2022, <<https://>

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

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

Watsen, K., "A YANG Data Model for a Truststore", Work in Progress, Internet-Draft, draft-ietf-netconf-trust-anchors-19, 19 October 2022, <<https://datatracker.ietf.org/doc/html/draft-ietf-netconf-trust-anchors-19>>.

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[RFC8342] Bjorklund, M., Schoenwaelder, J., Shafer, P., Watsen, K., and R. Wilton, "Network Management Datastore Architecture (NMDA)", RFC 8342, DOI 10.17487/RFC8342, March 2018, <<https://www.rfc-editor.org/info/rfc8342>>.

[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

This section is to be removed before publishing as an RFC.

A.1. 00 to 01

*Renamed "keychain" to "keystore".

A.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'.

A.3. 02 to 03

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

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

A.4. 03 to 04

*Added RFC 8174 to Requirements Language Section.

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

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

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

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

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

A.5. 04 to 05

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

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

A.6. 05 to 06

*Fixed change log missing section issue.

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

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

A.7. 06 to 07

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

*Added "random-selection" for reconnection-strategy's "starts-with" enum.

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

*Reduced the periodic-connection's "idle-timeout" from 5 to 2 minutes.

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

A.8. 07 to 08

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

A.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.

A.10. 09 to 10

*Reformatted YANG modules.

A.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.

A.12. 11 to 12

*Removed the 'must' statement limiting keepalives in periodic connections.

*Updated models and examples to reflect removal of the "demux" containers in the imported models.

*Updated the "periodic-connection" description statements to better describe behavior when connections are not closed gracefully.

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

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

*Replaced the 'listen', 'initiate', and 'call-home' features with boolean expressions.

A.13. 12 to 13

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

*In ietf-restconf-server, Added 'http-listen' (not https-listen) choice, to support case when server is behind a TLS-terminator.

*Refactored server module to be more like other 'server' models. If folks like it, will also apply to the client model, as well as to both the netconf client/server models. Now the 'restconf-server-grouping' is just the RC-specific bits (i.e., the "demux" container minus the container), 'restconf-server-[listen|callhome]-stack-grouping' is the protocol stack for a single connection, and 'restconf-server-app-grouping' is effectively what was before (both listen+callhome for many inbound/outbound endpoints).

A.14. 13 to 14

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

*Adjusting from change in TLS client model (removing the top-level 'certificate' container).

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

A.15. 14 to 15

*Added missing "or https-listen" clause in a "must" expression.

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

A.16. 15 to 16

*Added refinement to make "cert-to-name/fingerprint" be mandatory false.

*Commented out refinement to "tls-server-grouping/client-authentication" until a better "must" expression is defined.

*Updated restconf-client example to reflect that http-client-grouping no longer has a "protocol-version" leaf.

A.17. 16 to 17

Updated examples to include the "-key-format" nodes.

*Updated examples to remove the "required" nodes.

A.18. 17 to 18

*Updated examples to reflect new "bag" addition to truststore.

A.19. 18 to 19

*Updated examples to remove the 'algorithm' nodes.

*Updated examples to reflect the new TLS keepalives structure.

*Removed the 'protocol-versions' node from the restconf-server examples.

*Added a "Note to Reviewers" note to first page.

A.20. 19 to 20

*Moved and changed "must" statement so that either TLS *or* HTTP auth must be configured.

*Expanded "Data Model Overview section(s) [remove "wall" of tree diagrams].

*Updated the Security Considerations section.

A.21. 20 to 21

*Cleaned up titles in the IANA Considerations section

*Fixed issues found by the SecDir review of the "keystore" draft.

A.22. 21 to 22

*Addressed comments raised by YANG Doctor in the ct/ts/ks drafts.

A.23. 22 to 23

*Further clarified why some 'presence' statements are present.

*Addressed nits found in YANG Doctor reviews.

*Aligned modules with `pyang -f` formatting.

A.24. 23 to 24

*Removed Appendix A with fully-expanded tree diagrams.

*Replaced "base64encodedvalue==" with "BASE64VALUE=" in examples.

*Minor editorial nits

A.25. 24 to 25

*Fixed up the 'WG Web' and 'WG List' lines in YANG module(s)

*Fixed up copyright (i.e., s/Simplified/Revised/) in YANG module(s)

A.26. 25 to 26

*Added feature "central-restconf-client-supported" to top-level node "restconf-client".

*Added feature "central-restconf-server-supported" to top-level node "restconf-server".

A.27. 26 to 27

*Updated per Shepherd reviews impacting the suite of drafts.

*Added "max-wait" leaf to the "reconnect-strategy" nodes.

A.28. 27 to 28

*Updated per Shepherd reviews impacting the suite of drafts.

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