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RESTCONF Protocol
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Abstract

This document describes an HTTP-based protocol that provides a programmatic interface for accessing data defined in YANG, using the datastores defined in NETCONF.

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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Table of Contents

1. Introduction

There is a need for standard mechanisms to allow Web applications to access the configuration data, state data, data-model specific protocol operations, and event notifications within a networking device, in a modular and extensible manner.

This document defines an HTTP [RFC7230] based protocol called RESTCONF, for configuring data defined in YANG version 1 [RFC6020] or YANG version 1.1 [I-D.ietf-netmod-rfc6020bis], using datastores defined in NETCONF [RFC6241].

NETCONF defines configuration datastores and a set of Create, Retrieve, Update, Delete (CRUD) operations that can be used to access these datastores. The YANG language defines the syntax and semantics of datastore content, state data, protocol operations, and event notifications.

RESTCONF uses HTTP operations to provide CRUD operations on a conceptual datastore containing YANG-defined data, which is compatible with a server which implements NETCONF datastores.

If a RESTCONF server is co-located with a NETCONF server, then there are protocol interactions to be considered, as described in Section 1.4. The server MAY provide access to specific datastores using operation resources, as described in Section 3.6.

Configuration data and state data are exposed as resources that can be retrieved with the GET method. Resources representing configuration data can be modified with the DELETE, PATCH, POST, and PUT methods. Data is encoded with either XML [W3C.REC-xml-20081126] or JSON [RFC7159].

Data-model specific operations defined with the YANG "rpc" or "action" statements can be invoked with the POST method. Data-model specific event notifications defined with the YANG "notification" statement can be accessed.

1.1. Terminology

The keywords "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].

1.1.1. NETCONF

The following terms are defined in [RFC6241]:

- candidate configuration datastore
- client
- configuration data
- datastore
- configuration datastore
- protocol operation
- running configuration datastore
- server
- startup configuration datastore
- state data
- user

1.1.2. HTTP

The following terms are defined in [RFC3986]:

- fragment
- path
- query

The following terms are defined in [RFC7230]:

- header
- message-body
- request-line
- request URI
- status-line

The following terms are defined in [RFC7231]:

- method

- request
- resource

The following terms are defined in [RFC7232]:

- entity tag

1.1.3. YANG

The following terms are defined in [I-D.ietf-netmod-rfc6020bis]:

- action
- container
- data node
- key leaf
- leaf
- leaf-list
- list
- non-presence container (or NP-container)
- ordered-by user
- presence container (or P-container)
- RPC operation
- top-level data node

1.1.4. Terms

The following terms are used within this document:

- API resource: a resource with the media type "application/yang.api+xml" or "application/yang.api+json".
- data resource: a resource with the media type "application/yang.data+xml" or "application/yang.data+json". Containers, leafs, list entries, anydata and anyxml nodes can be data resources.

- datastore resource: a resource with the media type "application/yang.datastore+xml" or "application/yang.datastore+json". Represents a datastore.

- edit operation: a RESTCONF operation on a data resource using either a POST, PUT, PATCH, or DELETE method.

- event stream resource: This resource represents an SSE (Server-Sent Events) event stream. The content consists of text using the media type "text/event-stream", as defined by the HTML5 [W3C.REC-html5-20141028] specification. Each event represents one <notification> message generated by the server. It contains a conceptual system or data-model specific event that is delivered within an event notification stream. Also called a "stream resource".

- media-type: HTTP uses Internet media types [RFC2046] in the Content-Type and Accept header fields in order to provide open and extensible data typing and type negotiation.

- operation: the conceptual RESTCONF operation for a message, derived from the HTTP method, request URI, headers, and message-body.

- operation resource: a resource with the media type "application/yang.operation+xml" or "application/yang.operation+json".

- patch: a generic PATCH request on the target datastore or data resource. The media type of the message-body content will identify the patch type in use.

- plain patch: a specific PATCH request type that can be used for simple merge operations.

- query parameter: a parameter (and its value if any), encoded within the query component of the request URI.

- RESTCONF capability: An optional RESTCONF protocol feature supported by the server, which is identified by an IANA registered NETCONF Capability URI, and advertised with an entry in the "capability" leaf-list in Section 9.3.

- retrieval request: a request using the GET or HEAD methods.

- target resource: the resource that is associated with a particular message, identified by the "path" component of the request URI.

- schema resource: a resource with the media type "application/yang". The YANG representation of the schema can be retrieved by the client with the GET method.

- stream list: the set of data resource instances that describe the event stream resources available from the server. This information is defined in the "ietf-restconf-monitoring" module as the "stream" list. It can be retrieved using the target resource "{+restconf}/data/ietf-restconf-monitoring:restconf-state/streams/stream". The stream list contains information about each stream, such as the URL to retrieve the event stream data.

1.1.5. URI Template

Throughout this document, the URI template [RFC6570] syntax "{+restconf}" is used to refer to the RESTCONF API entry point outside of an example. See Section 3.1 for details.

For simplicity, all of the examples in this document assume "/restconf" as the discovered RESTCONF API root path.

1.1.6. Tree Diagrams

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

- Brackets "[" and "]" enclose list keys.

- Abbreviations before data node names: "rw" means configuration data (read-write) and "ro" state data (read-only).

- Symbols after data node names: "?" means an optional node, "!" means a presence container, and "*" denotes a list and leaf-list.

- Parentheses enclose choice and case nodes, and case nodes are also marked with a colon (":").

- Ellipsis ("...") stands for contents of subtrees that are not shown.

1.2. Subset of NETCONF Functionality

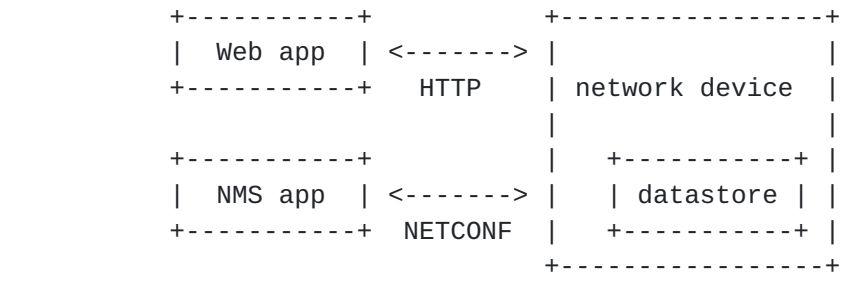
RESTCONF does not need to mirror the full functionality of the NETCONF protocol, but it does need to be compatible with NETCONF. RESTCONF achieves this by implementing a subset of the interaction capabilities provided by the NETCONF protocol, for instance, by eliminating datastores and explicit locking.

RESTCONF uses HTTP methods to implement the equivalent of NETCONF operations, enabling basic CRUD operations on a hierarchy of conceptual resources.

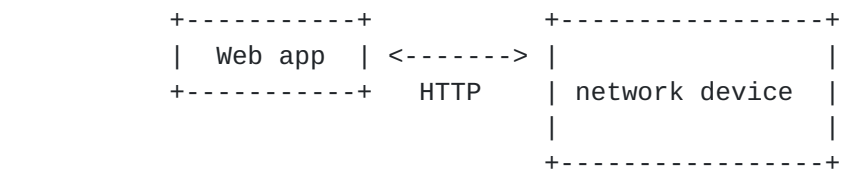
The HTTP POST, PUT, PATCH, and DELETE methods are used to edit data resources represented by YANG data models. These basic edit operations allow the running configuration to be altered in an all-or-none fashion.

RESTCONF is not intended to replace NETCONF, but rather provide an additional interface that follows Representational State Transfer (REST) principles [rest-dissertation], and is compatible with a resource-oriented device abstraction.

The following figure shows the system components if a RESTCONF server is co-located with a NETCONF server:



The following figure shows the system components if a RESTCONF server is implemented in a device that does not have a NETCONF server:



1.3. Data Model Driven API

RESTCONF combines the simplicity of the HTTP protocol with the predictability and automation potential of a schema-driven API. Using YANG, a client can predict all management resources, much like using URI Templates [RFC6570], but in a more holistic manner. This strategy obviates the need for responses provided by the server to contain Hypermedia as the Engine of Application State (HATEOAS) links, originally described in Roy Fielding's doctoral dissertation [rest-dissertation].

RESTCONF provides the YANG module capability information supported by the server, in case the client wants to use it. The URIs for custom

protocol operations and datastore content are predictable, based on the YANG module definitions.

The RESTCONF protocol operates on a conceptual datastore defined with the YANG data modeling language. The server lists each YANG module it supports using the "ietf-yang-library" YANG module, defined in [I-D.ietf-netconf-yang-library]. The server MUST implement the "ietf-yang-library" module, which MUST identify all the YANG modules used by the server.

The conceptual datastore contents, data-model-specific operations and event notifications are identified by this set of YANG modules.

The classification of data as configuration or non-configuration is derived from the YANG "config" statement. Data ordering behavior is derived from the YANG "ordered-by" statement.

The RESTCONF datastore editing model is simple and direct, similar to the behavior of the :writable-running capability in NETCONF. Each RESTCONF edit of a datastore resource is activated upon successful completion of the transaction.

1.4. Coexistence with NETCONF

RESTCONF can be implemented on a device that supports NETCONF.

If the device supports :writable-running, all edits to configuration nodes in {+restconf}/data are performed in the running configuration datastore. The URI template "{+restconf}" is defined in Section 1.1.5.

Otherwise, if the device supports :candidate, all edits to configuration nodes in {+restconf}/data are performed in the candidate configuration datastore. The candidate MUST be automatically committed to running immediately after each successful edit. Any edits from other sources that are in the candidate datastore will also be committed. If a confirmed-commit procedure is in progress, then this commit will act as the confirming commit. If the server is expecting a "persist-id" parameter to complete the confirmed commit procedure then the RESTCONF edit operation MUST fail with a "409 Conflict" status-line.

If the device supports :startup, the device MUST automatically update the non-volatile "startup datastore", after the running datastore has been updated as a consequence of a RESTCONF edit operation.

If a datastore that would be modified by a RESTCONF operation has an active lock, the RESTCONF edit operation MUST fail with a "409 Conflict" status-line.

1.5. RESTCONF Extensibility

There are two extensibility mechanisms built into RESTCONF:

- protocol version
- optional capabilities

This document defines version 1 of the RESTCONF protocol. If a future version of this protocol is defined, then that document will specify how the new version of RESTCONF is identified. It is expected that a different entry point {+restconf2} would be defined. The server will advertise all protocol versions that it supports in its host-meta data.

In this example, the server supports both RESTCONF version 1 and a fictitious version 2.

```
   Request
   -------
   GET /.well-known/host-meta HTTP/1.1
   Host: example.com
   Accept: application/xrd+xml

   Response
   --------
   HTTP/1.1 200 OK
   Content-Type: application/xrd+xml
   Content-Length: nnn

<XRD xmlns='http://docs.oasis-open.org/ns/xri/xrd-1.0'>
    <Link rel='restconf' href='/restconf'/>
    <Link rel='restconf2' href='/restconf2'/>
</XRD>
```

RESTCONF also supports a server-defined list of optional capabilities, which are listed by a server using the "ietf-restconf-monitoring" module defined in Section 9.3. For example, this document defines several query parameters in Section 4.8. Each optional parameter has a corresponding capability URI defined in Section 9.1.1 that is advertised by the server if supported.

The "capabilities" list can identify any sort of server extension. Typically this extension mechanism is used to identify optional query parameters but it is not limited to that purpose. For example, the "defaults" URI defined in Section 9.1.2 specifies a mandatory URI identifying server defaults handling behavior.

A new sub-resource type could be identified with a capability if it is optional to implement. Mandatory protocol features and new resource types require a new revision of the RESTCONF protocol.

2. Transport Protocol Requirements

2.1. Integrity and Confidentiality

HTTP [RFC7230] is an application layer protocol that may be layered on any reliable transport-layer protocol. RESTCONF is defined on top of HTTP, but due to the sensitive nature of the information conveyed, RESTCONF requires that the transport-layer protocol provides both data integrity and confidentiality. A RESTCONF server MUST support the TLS protocol [RFC5246]. The RESTCONF protocol MUST NOT be used over HTTP without using the TLS protocol.

HTTP/1.1 pipelining MUST be supported by the server. Responses MUST be sent in the same order that requests are received. No other versions of HTTP are supported for use with RESTCONF.

2.2. HTTPS with X.509v3 Certificates

Given the nearly ubiquitous support for HTTP over TLS [RFC7230], RESTCONF implementations MUST support the "https" URI scheme, which has the IANA assigned default port 443.

RESTCONF servers MUST present an X.509v3 based certificate when establishing a TLS connection with a RESTCONF client. The use the X.509v3 based certificates is consistent with NETCONF over TLS [RFC7589].

2.3. Certificate Validation

The RESTCONF client MUST either use X.509 certificate path validation [RFC5280] to verify the integrity of the RESTCONF server's TLS certificate, or match the presented X.509 certificate with locally configured certificate fingerprints.

The presented X.509 certificate MUST also be considered valid if it matches a locally configured certificate fingerprint. If X.509 certificate path validation fails and the presented X.509 certificate does not match a locally configured certificate fingerprint, the connection MUST be terminated as defined in [RFC5246].

2.4. Authenticated Server Identity

The RESTCONF client MUST check the identity of the server according to Section 6 of [RFC6125], including processing the outcome as described in Section 6.6 of [RFC6125].

2.5. Authenticated Client Identity

The RESTCONF server MUST authenticate client access to any protected resource. If the RESTCONF client is not authorized to access a resource, the server MUST send an HTTP response with "401 Unauthorized" status-line, as defined in Section 3.1 of [RFC7235].

To authenticate a client, a RESTCONF server MUST use TLS based client certificates (Section 7.4.6 of [RFC5246]), or MUST use any HTTP authentication scheme defined in the HTTP Authentication Scheme Registry (Section 5.1 in [RFC7235]). A server MAY also support the combination of both client certificates and an HTTP client authentication scheme, with the determination of how to process this combination left as an implementation decision.

The RESTCONF client identity derived from the authentication mechanism used is hereafter known as the "RESTCONF username" and subject to the NETCONF Access Control Module (NACM) [RFC6536]. When a client certificate is presented, the RESTCONF username MUST be derived using the algorithm defined in Section 7 of [RFC7589]. For all other cases, when HTTP authentication is used, the RESTCONF username MUST be provided by the HTTP authentication scheme used.

3. Resources

The RESTCONF protocol operates on a hierarchy of resources, starting with the top-level API resource itself (Section 3.1). Each resource represents a manageable component within the device.

A resource can be considered a collection of data and the set of allowed methods on that data. It can contain nested child resources. The child resource types and methods allowed on them are data-model specific.

A resource has a media type identifier, represented by the "Content-Type" header in the HTTP response message. A resource can

contain zero or more nested resources. A resource can be created and deleted independently of its parent resource, as long as the parent resource exists.

All RESTCONF resource types are defined in this document except specific datastore contents, protocol operations, and event notifications. The syntax and semantics for these resource types are defined in YANG modules.

The RESTCONF resources are accessed via a set of URIs defined in this document. The set of YANG modules supported by the server will determine the data model specific operations, top-level data nodes, and event notification messages supported by the server.

The RESTCONF protocol does not include a data resource discovery mechanism. Instead, the definitions within the YANG modules advertised by the server are used to construct a predictable operation or data resource identifier.

3.1. Root Resource Discovery

In line with the best practices defined by [RFC7320], RESTCONF enables deployments to specify where the RESTCONF API is located. When first connecting to a RESTCONF server, a RESTCONF client MUST determine the root of the RESTCONF API. There MUST be exactly one "restconf" link relation returned by the device.

The client discovers this by getting the "/.well-known/host-meta" resource ([RFC6415]) and using the <Link> element containing the "restconf" attribute :

Example returning /restconf:

```
   Request
   -------
   GET /.well-known/host-meta HTTP/1.1
   Host: example.com
   Accept: application/xrd+xml

   Response
   --------
   HTTP/1.1 200 OK
   Content-Type: application/xrd+xml
   Content-Length: nnn

<XRD xmlns='http://docs.oasis-open.org/ns/xri/xrd-1.0'>
    <Link rel='restconf' href='/restconf'/>
</XRD>
```

After discovering the RESTCONF API root, the client MUST prepend it to any subsequent request to a RESTCONF resource. In this example, the client would use the path "/restconf" as the RESTCONF entry point.

Example returning /top/restconf:

```
   Request
   -------
   GET /.well-known/host-meta HTTP/1.1
   Host: example.com
   Accept: application/xrd+xml

   Response
   --------
   HTTP/1.1 200 OK
   Content-Type: application/xrd+xml
   Content-Length: nnn

<XRD xmlns='http://docs.oasis-open.org/ns/xri/xrd-1.0'>
    <Link rel='restconf' href='/top/restconf'/>
</XRD>
```

In this example, the client would use the path "/top/restconf" as the RESTCONF entry point.

The client can now determine the operation resources supported by the the server. In this example a custom "play" operation is supported:

```
   Request
   -------
   GET /top/restconf/operations  HTTP/1.1
   Host: example.com
   Accept: application/yang.api+json

   Response
   --------
   HTTP/1.1 200 OK
   Date: Mon, 23 Apr 2012 17:01:00 GMT
   Server: example-server
   Cache-Control: no-cache
   Pragma: no-cache
   Last-Modified: Sun, 22 Apr 2012 01:00:14 GMT
   Content-Type: application/yang.api+json

   { "operations" : { "example-jukebox:play" : {} } }
```

If the XRD contains more than one link relation, then only the relation named "restconf" is relevant to this specification.

3.2. RESTCONF Media Types

The RESTCONF protocol defines a set of application specific media types to identify each of the available resource types. The following resource types are defined in RESTCONF:

Resource	Media Type
API	application/yang.api+xml
	application/yang.api+json
Datastore	application/yang.datastore+xml
	application/yang.datastore+json
Data	application/yang.data+xml
	application/yang.data+json
[none]	application/yang.errors+xml
	application/yang.errors+json
Operation	application/yang.operation+xml
	application/yang.operation+json
Schema	application/yang

RESTCONF Media Types

3.3. API Resource

The API resource contains the entry points for the RESTCONF datastore and operation resources. It is the top-level resource located at {+restconf} and has the media type "application/yang.api+xml" or "application/yang.api+json".

YANG Tree Diagram for an API Resource:

```
+--rw restconf
   +--rw data
   +--rw operations
   +--ro yang-library-version
```

The "application/yang.api" restconf-media-type extension in the "ietf-restconf" module defined in Section 8 is used to specify the structure and syntax of the conceptual child resources within the API resource.

The API resource can be retrieved with the GET method.

This resource has the following child resources:

Child Resource	Description
data	Contains all data resources
operations	Data-model specific operations
yang-library-version	ietf-yang-library module date

RESTCONF API Resource

3.3.1. {+restconf}/data

This mandatory resource represents the combined configuration and state data resources that can be accessed by a client. It cannot be created or deleted by the client. The datastore resource type is defined in Section 3.4.

Example:

This example request by the client would retrieve only the non-configuration data nodes that exist within the "library" resource, using the "content" query parameter (see Section 4.8.1).

```
GET /restconf/data/example-jukebox:jukebox/library
    ?content=nonconfig  HTTP/1.1
Host: example.com
Accept: application/yang.data+xml
```

The server might respond:

```
HTTP/1.1 200 OK
Date: Mon, 23 Apr 2012 17:01:30 GMT
Server: example-server
Cache-Control: no-cache
Pragma: no-cache
Content-Type: application/yang.data+xml

<library xmlns="https://example.com/ns/example-jukebox">
  <artist-count>42</artist-count>
  <album-count>59</album-count>
  <song-count>374</song-count>
</library>
```

3.3.2. {+restconf}/operations

This optional resource is a container that provides access to the data-model specific protocol operations supported by the server. The server MAY omit this resource if no data-model specific operations are advertised.

Any data-model specific protocol operations defined in the YANG modules advertised by the server MUST be available as child nodes of this resource.

Operation resources are defined in Section 3.6.

3.3.3. {+restconf}/yang-library-version

This mandatory leaf identifies the revision date of the "ietf-yang-library" YANG module that is implemented by this server.

Example:

```
GET /restconf/yang-library-version  HTTP/1.1
Host: example.com
Accept: application/yang.data+xml
```

The server might respond (response wrapped for display purposes):

```
HTTP/1.1 200 OK
Date: Mon, 23 Apr 2012 17:01:30 GMT
Server: example-server
Cache-Control: no-cache
Pragma: no-cache
Content-Type: application/yang.data+xml

<yang-library-version
  xmlns="urn:ietf:params:xml:ns:yang:ietf-yang-library">
  2016-04-09
</yang-library-version>
```

3.4. Datastore Resource

The "{+restconf}/data" subtree represents the datastore resource type, which is a collection of configuration data and state data nodes.

This resource type is an abstraction of the system's underlying datastore implementation. It is used to simplify resource editing for the client. The RESTCONF datastore resource is a conceptual collection of all configuration and state data that is present on the device.

Configuration edit transaction management and configuration persistence are handled by the server and not controlled by the client. A datastore resource can be written directly with the POST and PATCH methods. Each RESTCONF edit of a datastore resource is saved to non-volatile storage by the server, if the server supports non-volatile storage of configuration data.

3.4.1. Edit Collision Detection

Two "edit collision detection" mechanisms are provided in RESTCONF, for datastore and data resources.

3.4.1.1. Timestamp

The last change time is maintained and the "Last-Modified" ([RFC7232], Section 2.2) header is returned in the response for a retrieval request. The "If-Unmodified-Since" header can be used in edit operation requests to cause the server to reject the request if the resource has been modified since the specified timestamp.

The server SHOULD maintain a last-modified timestamp for the top-level {+restconf}/data resource. This timestamp is only affected by configuration data resources, and MUST NOT be updated for changes to non-configuration data.

3.4.1.2. Entity tag

A unique opaque string is maintained and the "ETag" ([RFC7232], Section 2.3) header is returned in the response for a retrieval request. The "If-Match" header can be used in edit operation requests to cause the server to reject the request if the resource entity tag does not match the specified value.

The server MUST maintain an entity tag for the top-level {+restconf}/data resource. This entity tag is only affected by configuration data resources, and MUST NOT be updated for changes to non-configuration data.

3.4.1.3. Update Procedure

Changes to configuration data resources affect the timestamp and entity tag to that resource, any ancestor data resources, and the datastore resource.

For example, an edit to disable an interface might be done by setting the leaf "/interfaces/interface/enabled" to "false". The "enabled" data node and its ancestors (one "interface" list instance, and the "interfaces" container) are considered to be changed. The datastore

is considered to be changed when any top-level configuration data node is changed (e.g., "interfaces").

3.5. Data Resource

A data resource represents a YANG data node that is a descendant node of a datastore resource. Each YANG-defined data node can be uniquely targeted by the request-line of an HTTP operation. Containers, leafs, leaf-list entries, list entries, anydata and anyxml nodes are data resources.

The representation maintained for each data resource is the YANG defined subtree for that node. HTTP operations on a data resource affect both the targeted data node and all its descendants, if any.

For configuration data resources, the server MAY maintain a last-modified timestamp for the resource, and return the "Last-Modified" header when it is retrieved with the GET or HEAD methods.

The "Last-Modified" header information can be used by a RESTCONF client in subsequent requests, within the "If-Modified-Since" and "If-Unmodified-Since" headers.

If maintained, the resource timestamp MUST be set to the current time whenever the resource or any configuration resource within the resource is altered. If not maintained, then the resource timestamp for the datastore MUST be used instead.

This timestamp is only affected by configuration data resources, and MUST NOT be updated for changes to non-configuration data.

For configuration data resources, the server SHOULD maintain a resource entity tag for the resource, and return the "ETag" header when it is retrieved as the target resource with the GET or HEAD methods. If maintained, the resource entity tag MUST be updated whenever the resource or any configuration resource within the resource is altered. If not maintained, then the resource entity tag for the datastore MUST be used instead.

The "ETag" header information can be used by a RESTCONF client in subsequent requests, within the "If-Match" and "If-None-Match" headers.

This entity tag is only affected by configuration data resources, and MUST NOT be updated for changes to non-configuration data.

A data resource can be retrieved with the GET method. Data resources are accessed via the "{+restconf}/data" entry point. This sub-tree is used to retrieve and edit data resources.

A configuration data resource can be altered by the client with some or all of the edit operations, depending on the target resource and the specific operation. Refer to Section 4 for more details on edit operations.

3.5.1. Encoding Data Resource Identifiers in the Request URI

In YANG, data nodes are identified with an absolute XPath expression, defined in [XPath], starting from the document root to the target resource. In RESTCONF, URI-encoded path expressions are used instead.

A predictable location for a data resource is important, since applications will code to the YANG data model module, which uses static naming and defines an absolute path location for all data nodes.

A RESTCONF data resource identifier is not an XPath expression. It is encoded from left to right, starting with the top-level data node, according to the "api-path" rule in Section 3.5.1.1. The node name of each ancestor of the target resource node is encoded in order, ending with the node name for the target resource. If a node in the path is defined in another module than its parent node, then module name followed by a colon character (":") is prepended to the node name in the resource identifier. See Section 3.5.1.1 for details.

If a data node in the path expression is a YANG leaf-list node, then the leaf-list value MUST be encoded according to the following rules:

- The instance-identifier for the leaf-list MUST be encoded using one path segment [RFC3986].

- The path segment is constructed by having the leaf-list name, followed by an "=" character, followed by the leaf-list value. (e.g., /restconf/data/top-leaflist=fred).

If a data node in the path expression is a YANG list node, then the key values for the list (if any) MUST be encoded according to the following rules:

- The key leaf values for a data resource representing a YANG list MUST be encoded using one path segment [RFC3986].

- If there is only one key leaf value, the path segment is constructed by having the list name, followed by an "=" character, followed by the single key leaf value.

- If there are multiple key leaf values, the path segment is constructed by having the list name, followed by the value of each leaf identified in the "key" statement, encoded in the order specified in the YANG "key" statement. Each key leaf value except the last one is followed by a comma character.

- The key value is specified as a string, using the canonical representation for the YANG data type. Any reserved characters MUST be percent-encoded, according to [RFC3986], section 2.1.

- All the components in the "key" statement MUST be encoded. Partial instance identifiers are not supported.

- Since missing key values are not allowed, two consecutive commas are interpreted as a zero-length string. (example: list=foo,,baz).

- The "list-instance" ABNF rule defined in Section 3.5.1.1 represents the syntax of a list instance identifier.

- Resource URI values returned in Location headers for data resources MUST identify the module name, even if there are no conflicting local names when the resource is created. This ensures the correct resource will be identified even if the server loads a new module that the old client does not know about.

Examples:

```
container top {
    list list1 {
        key "key1 key2 key3";
         ...
         list list2 {
             key "key4 key5";
             ...
             leaf X { type string; }
         }
     }
     leaf-list Y {
       type uint32;
     }
 }
```

For the above YANG definition, a target resource URI for leaf "X" would be encoded as follows (line wrapped for display purposes only):

```
 /restconf/data/example-top:top/list1=key1,key2,key3/
    list2=key4,key5/X
```

For the above YANG definition, a target resource URI for leaf-list "Y" would be encoded as follows:

```
 /restconf/data/example-top:top/Y=instance-value
```

The following example shows how reserved characters are percent-encoded within a key value. The value of "key1" contains a comma, single-quote, double-quote, colon, double-quote, space, and forward slash. (,'":" /). Note that double-quote is not a reserved characters and does not need to be percent-encoded. The value of "key2" is the empty string, and the value of "key3" is the string "foo".

Example URL:

```
/restconf/data/example-top:top/list1=%2C%27"%3A"%20%2F,,foo
```

3.5.1.1. ABNF For Data Resource Identifiers

The "api-path" Augmented Backus-Naur Form (ABNF) syntax is used to construct RESTCONF path identifiers:

```
    api-path = "/"  |
               ("/" api-identifier
                 0*("/" (api-identifier | list-instance )))

    api-identifier = [module-name ":"] identifier   ;; note 1

    module-name = identifier

    list-instance = api-identifier "=" key-value ["," key-value]*

    key-value = string      ;; note 1

    string = <a quoted or unquoted string>

    ;; An identifier MUST NOT start with
    ;; (('X'|'x') ('M'|'m') ('L'|'l'))
    identifier  = (ALPHA / "_")
                  *(ALPHA / DIGIT / "_" / "-" / ".")
```

Note 1: The syntax for "api-identifier" and "key-value" MUST conform to the JSON identifier encoding rules in Section 4 of [I-D.ietf-netmod-yang-json].

3.5.2. Defaults Handling

RESTCONF requires that a server report its default handling mode (see Section 9.1.2 for details). If the optional "with-defaults" query parameter is supported by the server, a client may use it to control retrieval of default values (see Section 4.8.9 for details).

If a leaf or leaf-list is missing from the configuration and there is a YANG-defined default for that data resource, then the server MUST use the YANG-defined default as the configured value.

If the target of a GET method is a data node that represents a leaf that has a default value, and the leaf has not been configured yet, the server MUST return the default value that is in use by the server.

If the target of a GET method is a data node that represents a container or list that has any child resources with default values, for the child resources that have not been given value yet, the server MAY return the default values that are in use by the server, in accordance with its reported default handing mode and query parameters passed by the client.

3.6. Operation Resource

An operation resource represents a protocol operation defined with the YANG "rpc" statement or a data-model specific action defined with a YANG "action" statement. It is invoked using a POST method on the operation resource.

An RPC operation is invoked as:

POST {+restconf}/operations/<operation>

The <operation> field identifies the module name and rpc identifier string for the desired operation.

For example, if "module-A" defined a "reset" rpc operation, then invoking the operation from "module-A" would be requested as follows:

```
POST /restconf/operations/module-A:reset HTTP/1.1
Server example.com
```

An action is invoked as:

POST {+restconf}/data/<data-resource-identifier>/<action>

where <data-resource-identifier> contains the path to the data node where the action is defined, and <action> is the name of the action.

For example, if "module-A" defined a "reset-all" action in the container "interfaces", then invoking this action would be requested as follows:

```
POST /restconf/data/module-A:interfaces/reset-all HTTP/1.1
Server example.com
```

If the "rpc" or "action" statement has an "input" section, then a message-body MAY be sent by the client in the request, otherwise the request message MUST NOT include a message-body. If the "input" objcet tree contains mandatory parameters, then a message-body MUST be sent by the client. A mandatory parameter is a leaf or choice with a "mandatory" statement set to "true", or a list or leaf-list than have a "min-elements" statement value greater than zero.

If the operation is invoked without errors, and if the "rpc" or "action" statement has an "output" section, then a message-body MAY be sent by the server in the response, otherwise the response message MUST NOT include a message-body in the response message, and MUST send a "204 No Content" status-line instead.

If the operation input is not valid, or the operation is invoked but errors occur, then a message-body MUST be sent by the server, containing an "errors" resource, as defined in Section 3.9. A detailed example of an operation resource error response can be found in Section 3.6.3.

All operation resources representing RPC operations supported by the server MUST be identified in the {+restconf}/operations subtree defined in Section 3.3.2. Operation resources representing YANG actions are not identified in this subtree since they are invoked using a URI within the {+restconf}/data subtree.

3.6.1. Encoding Operation Resource Input Parameters

If the "rpc" or "action" statement has an "input" section, then the "input" node is provided in the message-body, corresponding to the YANG data definition statements within the "input" section.

Examples:

The following YANG module is used for the RPC operation examples in this section.

```
module example-ops {
  namespace "https://example.com/ns/example-ops";
  prefix "ops";
  revision "2016-03-10";

  rpc reboot {
    input {
      leaf delay {
        units seconds;
        type uint32;
        default 0;
      }
      leaf message { type string; }
      leaf language { type string; }
    }
  }

  rpc get-reboot-info {
    output {
      leaf reboot-time {
        units seconds;
        type uint32;
      }
      leaf message { type string; }
      leaf language { type string; }
    }
  }
}
```

The following YANG module is used for the YANG action examples in this section.

```
module example-actions {
  yang-version 1.1;
  namespace "https://example.com/ns/example-actions";
  prefix "act";
  import ietf-yang-types { prefix yang; }
  revision "2016-03-10";

  container interfaces {
    list interface {
      key name;
      leaf name { type string; }

      action reset {
        input {
          leaf delay {
```

```
              units seconds;
              type uint32;
              default 0;
            }
          }
        }

        action get-last-reset-time {
          output {
            leaf last-reset {
              type yang:date-and-time;
              mandatory true;
            }
          }
        }
      }
    }

  }
```

RPC Input Example:

The client might send the following POST request message to invoke the "reboot" RPC operation:

```
POST /restconf/operations/example-ops:reboot HTTP/1.1
Host: example.com
Content-Type: application/yang.operation+xml

<input xmlns="https://example.com/ns/example-ops">
 <delay>600</delay>
 <message>Going down for system maintenance</message>
 <language>en-US</language>
</input>
```

The server might respond:

```
HTTP/1.1 204 No Content
Date: Mon, 25 Apr 2012 11:01:00 GMT
Server: example-server
```

The same example request message is shown here using JSON encoding:

```
   POST /restconf/operations/example-ops:reboot HTTP/1.1
   Host: example.com
   Content-Type: application/yang.operation+json
```

```
    {
      "example-ops:input" : {
        "delay" : 600,
        "message" : "Going down for system maintenance",
        "language" : "en-US"
      }
    }
```

Action Input Example:

The client might send the following POST request message to invoke the "reset" action (text wrap for display purposes):

```
POST /restconf/data/example-actions:interfaces/interface=eth0
  /reset HTTP/1.1
Host: example.com
Content-Type: application/yang.operation+xml

<input xmlns="https://example.com/ns/example-actions">
  <delay>600</delay>
</input>
```

The server might respond:

```
HTTP/1.1 204 No Content
Date: Mon, 25 Apr 2012 11:01:00 GMT
Server: example-server
```

The same example request message is shown here using JSON encoding (text wrap for display purposes):

```
   POST /restconf/data/example-actions:interfaces/interface=eth0
     /reset HTTP/1.1
   Host: example.com
   Content-Type: application/yang.operation+json

   { "example-actions:input" : {
       "delay" : 600
     }
   }
```

3.6.2. Encoding Operation Resource Output Parameters

If the "rpc" or "action" statement has an "output" section, then the "output" node is provided in the message-body, corresponding to the YANG data definition statements within the "output" section.

The request URI is not returned in the response. This URI might have context information required to associate the output to the specific "rpc" or "action" statement used in the request.

Examples:

RPC Output Example:

The "example-ops" YANG module defined in Section 3.6.1 is used for this example.

The client might send the following POST request message to invoke the "get-reboot-info" operation:

```
POST /restconf/operations/example-ops:get-reboot-info HTTP/1.1
Host: example.com
Accept: application/yang.operation+json
```

The server might respond:

```
   HTTP/1.1 200 OK
   Date: Mon, 25 Apr 2012 11:10:30 GMT
   Server: example-server
   Content-Type: application/yang.operation+json

   {
     "example-ops:output" : {
       "reboot-time" : 30,
       "message" : "Going down for system maintenance",
       "language" : "en-US"
     }
   }
```

The same response is shown here using XML encoding:

```
HTTP/1.1 200 OK
Date: Mon, 25 Apr 2012 11:10:30 GMT
Server: example-server
Content-Type: application/yang.operation+xml

<output xmlns="https://example.com/ns/example-ops">
  <reboot-time>30</reboot-time>
  <message>Going down for system maintenance</message>
  <language>en-US</language>
</output>
```

Action Output Example:

The "example-actions" YANG module defined in Section 3.6.1 is used for this example.

The client might send the following POST request message to invoke the "get-last-reset-time" action:

```
POST /restconf/data/example-actions:interfaces/interface=eth0
   /get-last-reset-time HTTP/1.1
Host: example.com
Accept: application/yang.operation+json
```

The server might respond:

```
   HTTP/1.1 200 OK
   Date: Mon, 25 Apr 2012 11:10:30 GMT
   Server: example-server
   Content-Type: application/yang.operation+json

   {
     "example-actions:output" : {
       "last-reset" : "2015-10-10T02:14:11Z"
     }
   }
```

3.6.3. Encoding Operation Resource Errors

If any errors occur while attempting to invoke the operation or action, then an "errors" media type is returned with the appropriate error status.

Using the "reboot" operation from the example in Section 3.6.1, the client might send the following POST request message:

```
POST /restconf/operations/example-ops:reboot HTTP/1.1
Host: example.com
Content-Type: application/yang.operation+xml

<input xmlns="https://example.com/ns/example-ops">
  <delay>-33</delay>
  <message>Going down for system maintenance</message>
  <language>en-US</language>
</input>
```

The server might respond with an "invalid-value" error:

```
HTTP/1.1 400 Bad Request
Date: Mon, 25 Apr 2012 11:10:30 GMT
Server: example-server
Content-Type: application/yang.errors+xml

<errors xmlns="urn:ietf:params:xml:ns:yang:ietf-restconf">
  <error>
    <error-type>protocol</error-type>
    <error-tag>invalid-value</error-tag>
    <error-path xmlns:ops="https://example.com/ns/example-ops">
      /ops:input/ops:delay
    </error-path>
    <error-message>Invalid input parameter</error-message>
  </error>
</errors>
```

The same response is shown here in JSON encoding:

```
   HTTP/1.1 400 Bad Request
   Date: Mon, 25 Apr 2012 11:10:30 GMT
   Server: example-server
   Content-Type: application/yang.errors+json

   { "ietf-restconf:errors" : {
       "error" : [
         {
           "error-type" : "protocol",
           "error-tag" : "invalid-value",
           "error-path" : "/example-ops:input/delay",
           "error-message" : "Invalid input parameter",
         }
       ]
     }
   }
```

3.7. Schema Resource

The server can optionally support retrieval of the YANG modules it supports. If retrieval is supported, then the "schema" leaf MUST be present in the associated "module" list entry, defined in [I-D.ietf-netconf-yang-library].

To retrieve a YANG module, a client first needs to get the URL for retrieving the schema, which is stored in the "schema" leaf. Note that there is no required structure for this URL. The URL value shown below is just an example.

The client might send the following GET request message:

```
GET /restconf/data/ietf-yang-library:modules/module=
    example-jukebox,2015-04-04/schema HTTP/1.1
Host: example.com
Accept: application/yang.data+json
```

The server might respond:

```
   HTTP/1.1 200 OK
   Date: Thu, 11 Feb 2016 11:10:30 GMT
   Server: example-server
   Content-Type: application/yang.data+json

   {
     "ietf-yang-library:schema":
      "https://example.com/mymodules/example-jukebox/2015-04-04"
   }
```

Next the client needs to retrieve the actual YANG schema.

The client might send the following GET request message:

```
GET https://example.com/mymodules/example-jukebox/2015-04-04
   HTTP/1.1
Host: example.com
Accept: application/yang
```

The server might respond:

```
   HTTP/1.1 200 OK
   Date: Thu, 11 Feb 2016 11:10:31 GMT
   Server: example-server
   Content-Type: application/yang

   module example-jukebox {

      // contents of YANG module deleted for this example...

   }
```

3.8. Event Stream Resource

An "event stream" resource represents a source for system generated event notifications. Each stream is created and modified by the server only. A client can retrieve a stream resource or initiate a long-poll server sent event stream, using the procedure specified in Section 6.3.

A notification stream functions according to the NETCONF Notifications specification [RFC5277]. The available streams can be retrieved from the stream list, which specifies the syntax and semantics of a stream resource.

3.9. Errors Media Type

An "errors" media type is a collection of error information that is sent as the message-body in a server response message, if an error occurs while processing a request message. It is not considered a resource type because no instances can be retrieved with a GET request.

The "ietf-restconf" YANG module contains the "application/yang.errors" restconf-media-type extension which specifies the syntax and semantics of an "errors" media type. RESTCONF error handling behavior is defined in Section 7.

4. Operations

The RESTCONF protocol uses HTTP methods to identify the CRUD operation requested for a particular resource.

The following table shows how the RESTCONF operations relate to NETCONF protocol operations:

RESTCONF	NETCONF
OPTIONS	none
HEAD	none
GET	<get-config>, <get>
POST	<edit-config> (operation="create")
POST	invoke any operation
PUT	<edit-config> (operation="create/replace")
PATCH	<edit-config> (operation="merge")
DELETE	<edit-config> (operation="delete")

CRUD Methods in RESTCONF

The NETCONF "remove" operation attribute is not supported by the HTTP DELETE method. The resource must exist or the DELETE method will fail. The PATCH method is equivalent to a "merge" operation when using a plain patch (see Section 4.6.1); other media-types may provide more granular control.

Access control mechanisms MUST be used to limit what operations can be used. In particular, RESTCONF is compatible with the NETCONF Access Control Model (NACM) [RFC6536], as there is a specific mapping between RESTCONF and NETCONF operations, defined in Section 4. The resource path needs to be converted internally by the server to the corresponding YANG instance-identifier. Using this information, the server can apply the NACM access control rules to RESTCONF messages.

The server MUST NOT allow any operation to any resources that the client is not authorized to access.

Operations are applied to a single data resource instance at once. The server MUST NOT allow any operation to be applied to multiple instances of a YANG list or leaf-list.

Implementation of all methods (except PATCH) are defined in [RFC7231]. This section defines the RESTCONF protocol usage for each HTTP method.

4.1. OPTIONS

The OPTIONS method is sent by the client to discover which methods are supported by the server for a specific resource (e.g., GET, POST, DELETE, etc.). The server MUST implement this method.

If the PATCH method is supported, then the "Accept-Patch" header MUST be supported and returned in the response to the OPTIONS request, as defined in [RFC5789].

4.2. HEAD

The HEAD method is sent by the client to retrieve just the headers that would be returned for the comparable GET method, without the response message-body. It is supported for all resource types, except operation resources.

The request MUST contain a request URI that contains at least the entry point. The same query parameters supported by the GET method are supported by the HEAD method.

The access control behavior is enforced as if the method was GET instead of HEAD. The server MUST respond the same as if the method was GET instead of HEAD, except that no response message-body is included.

4.3. GET

The GET method is sent by the client to retrieve data and meta-data for a resource. It is supported for all resource types, except operation resources. The request MUST contain a request URI that contains at least the entry point.

The server MUST NOT return any data resources for which the user does not have read privileges. If the user is not authorized to read the target resource, an error response containing a "401 Unauthorized" status-line SHOULD be returned. A server MAY return a "404 Not Found" status-line, as described in section 6.5.3 in [RFC7231].

If the user is authorized to read some but not all of the target resource, the unauthorized content is omitted from the response message-body, and the authorized content is returned to the client.

If any content is returned to the client, then the server MUST send a valid response message-body. More than one element MUST NOT be returned for XML encoding.

If a retrieval request for a data resource representing a YANG leaf-list or list object identifies more than one instance, and XML encoding is used in the response, then an error response containing a "400 Bad Request" status-line MUST be returned by the server.

If the target resource of a retrieval request is for an operation resource then a "405 Method Not Allowed" status-line MUST be returned by the server.

Note that the way that access control is applied to data resources is completely incompatible with HTTP caching. The Last-Modified and ETag headers maintained for a data resource are not affected by changes to the access control rules for that data resource. It is possible for the representation of a data resource that is visible to a particular client to be changed without detection via the Last-Modified or ETag values.

Example:

The client might request the response headers for an XML representation of the a specific "album" resource:

```
GET /restconf/data/example-jukebox:jukebox/
   library/artist=Foo%20Fighters/album=Wasting%20Light  HTTP/1.1
Host: example.com
Accept: application/yang.data+xml
```

The server might respond:

```
HTTP/1.1 200 OK
Date: Mon, 23 Apr 2012 17:02:40 GMT
Server: example-server
Content-Type: application/yang.data+xml
Cache-Control: no-cache
Pragma: no-cache
ETag: a74eefc993a2b
Last-Modified: Mon, 23 Apr 2012 11:02:14 GMT

<album xmlns="http://example.com/ns/example-jukebox"
       xmlns:jbox="http://example.com/ns/example-jukebox">
  <name>Wasting Light</name>
  <genre>jbox:alternative</genre>
  <year>2011</year>
</album>
```

4.4. POST

The POST method is sent by the client to create a data resource or invoke an operation resource. The server uses the target resource media type to determine how to process the request.

Type	Description
Datastore	Create a top-level configuration data resource
Data	Create a configuration data child resource
Operation	Invoke a protocol operation

Resource Types that Support POST

4.4.1. Create Resource Mode

If the target resource type is a datastore or data resource, then the POST is treated as a request to create a top-level resource or child resource, respectively. The message-body is expected to contain the content of a child resource to create within the parent (target resource). The message-body MUST NOT contain more than one instance of the expected data resource. The data-model for the child tree is the subtree as defined by YANG for the child resource.

The "insert" and "point" query parameters MUST be supported by the POST method for datastore and data resources. These parameters are only allowed if the list or leaf-list is ordered-by user.

If the POST method succeeds, a "201 Created" status-line is returned and there is no response message-body. A "Location" header

identifying the child resource that was created MUST be present in the response in this case.

If the data resource already exists, then the POST request MUST fail and a "409 Conflict" status-line MUST be returned.

If the user is not authorized to create the target resource, an error response containing a "403 Forbidden" status-line SHOULD be returned. A server MAY return a "404 Not Found" status-line, as described in section 6.5.3 in [RFC7231]. All other error responses are handled according to the procedures defined in Section 7.

Example:

To create a new "jukebox" resource, the client might send:

```
POST /restconf/data HTTP/1.1
Host: example.com
Content-Type: application/yang.data+json

{ "example-jukebox:jukebox" : {} }
```

If the resource is created, the server might respond as follows. Note that the "Location" header line is wrapped for display purposes only:

```
HTTP/1.1 201 Created
Date: Mon, 23 Apr 2012 17:01:00 GMT
Server: example-server
Location: https://example.com/restconf/data/
    example-jukebox:jukebox
Last-Modified: Mon, 23 Apr 2012 17:01:00 GMT
ETag: b3a3e673be2
```

Refer to Appendix D.2.1 for more resource creation examples.

4.4.2. Invoke Operation Mode

If the target resource type is an operation resource, then the POST method is treated as a request to invoke that operation. The message-body (if any) is processed as the operation input parameters. Refer to Section 3.6 for details on operation resources.

If the POST request succeeds, a "200 OK" status-line is returned if there is a response message-body, and a "204 No Content" status-line is returned if there is no response message-body.

If the user is not authorized to invoke the target operation, an error response containing a "403 Forbidden" status-line is returned to the client. All other error responses are handled according to the procedures defined in Section 7.

Example:

In this example, the client is invoking the "play" operation defined in the "example-jukebox" YANG module.

A client might send a "play" request as follows:

```
POST /restconf/operations/example-jukebox:play   HTTP/1.1
Host: example.com
Content-Type: application/yang.operation+json

{
  "example-jukebox:input" : {
    "playlist" : "Foo-One",
    "song-number" : 2
  }
}
```

The server might respond:

```
HTTP/1.1 204 No Content
Date: Mon, 23 Apr 2012 17:50:00 GMT
Server: example-server
```

4.5. PUT

The PUT method is sent by the client to create or replace the target data resource. A request message-body MUST be present, representing the new data resource, or the server MUST return "400 Bad Request" status-line.

The only target resource media type that supports PUT is the data resource. The message-body is expected to contain the content used to create or replace the target resource.

The "insert" (Section 4.8.5) and "point" (Section 4.8.6) query parameters MUST be supported by the PUT method for data resources. These parameters are only allowed if the list or leaf-list is ordered-by user.

Consistent with [RFC7231], if the PUT request creates a new resource, a "201 Created" status-line is returned. If an existing resource is modified, a "204 No Content" status-line is returned.

If the user is not authorized to create or replace the target resource an error response containing a "403 Forbidden" status-line SHOULD be returned. A server MAY return a "404 Not Found" status-line, as described in section 6.5.3 in [RFC7231]. All other error responses are handled according to the procedures defined in Section 7.

If the target resource represents a YANG leaf-list, then the PUT method MUST NOT change the value of the leaf-list instance.

If the target resource represents a YANG list instance, then the PUT method MUST NOT change any key leaf values in the message-body representation.

Example:

An "album" child resource defined in the "example-jukebox" YANG module is replaced or created if it does not already exist.

To replace the "album" resource contents, the client might send as follows. Note that the request-line is wrapped for display purposes only:

```
PUT /restconf/data/example-jukebox:jukebox/
    library/artist=Foo%20Fighters/album=Wasting%20Light   HTTP/1.1
Host: example.com
Content-Type: application/yang.data+json

{
  "example-jukebox:album" : {
    "name" : "Wasting Light",
    "genre" : "example-jukebox:alternative",
    "year" : 2011
  }
}
```

If the resource is updated, the server might respond:

```
HTTP/1.1 204 No Content
Date: Mon, 23 Apr 2012 17:04:00 GMT
Server: example-server
Last-Modified: Mon, 23 Apr 2012 17:04:00 GMT
ETag: b27480aeda4c
```

The same request is shown here using XML encoding:

```
PUT /restconf/data/example-jukebox:jukebox/
    library/artist=Foo%20Fighters/album=Wasting%20Light   HTTP/1.1
```

```
Host: example.com
Content-Type: application/yang.data+xml

<album xmlns="http://example.com/ns/example-jukebox"
       xmlns:jbox="http://example.com/ns/example-jukebox">
  <name>Wasting Light</name>
  <genre>jbox:alternative</genre>
  <year>2011</year>
</album>
```

4.6. PATCH

RESTCONF uses the HTTP PATCH method defined in [RFC5789] to provide an extensible framework for resource patching mechanisms. It is optional to implement by the server. Each patch mechanism needs a unique media type. Zero or more patch media types MAY be supported by the server. The media types supported by a server can be discovered by the client by sending an OPTIONS request (see Section 4.1).

This document defines one patch mechanism (Section 4.6.1). The YANG PATCH mechanism is defined in [I-D.ietf-netconf-yang-patch]. Other patch mechanisms may be defined by future specifications.

If the target resource instance does not exist, the server MUST NOT create it.

If the PATCH request succeeds, a "200 OK" status-line is returned if there is a message-body, and "204 No Content" is returned if no response message-body is sent.

If the user is not authorized to alter the target resource an error response containing a "403 Forbidden" status-line SHOULD be returned. A server MAY return a "404 Not Found" status-line, as described in section 6.5.3 in [RFC7231]. All other error responses are handled according to the procedures defined in Section 7.

4.6.1. Plain Patch

The plain patch mechanism merges the contents of the message body with the target resource. If the target resource is a datastore resource (see Section 3.4), the message body MUST be either application/yang.datastore+xml or application/yang.datastore+json. If then the target resource is a data resource (see Section 3.5), then the message body MUST be either application/yang.data+xml or application/yang.data+json.

Plain patch can be used to create or update, but not delete, a child resource within the target resource. Please see [I-D.ietf-netconf-yang-patch] for an alternate media-type supporting more granular control. The YANG Patch Media Type allows multiple sub-operations (e.g., merge, delete) within a single PATCH operation.

If the target resource represents a YANG leaf-list, then the PATCH method MUST not change the value of the leaf-list instance.

If the target resource represents a YANG list instance, then the PATCH method MUST NOT change any key leaf values in the message-body representation.

Example:

To replace just the "year" field in the "album" resource (instead of replacing the entire resource with the PUT method), the client might send a plain patch as follows. Note that the request-line is wrapped for display purposes only:

```
PATCH /restconf/data/example-jukebox:jukebox/
    library/artist=Foo%20Fighters/album=Wasting%20Light HTTP/1.1
Host: example.com
If-Match: b8389233a4c
Content-Type: application/yang.data+xml

<album xmlns="http://example.com/ns/example-jukebox">
 <year>2011</year>
</album>
```

If the field is updated, the server might respond:

```
HTTP/1.1 204 No Content
Date: Mon, 23 Apr 2012 17:49:30 GMT
Server: example-server
Last-Modified: Mon, 23 Apr 2012 17:49:30 GMT
ETag: b2788923da4c
```

4.7. DELETE

The DELETE method is used to delete the target resource. If the DELETE request succeeds, a "204 No Content" status-line is returned, and there is no response message-body.

If the user is not authorized to delete the target resource then an error response containing a "403 Forbidden" status-line SHOULD be returned. A server MAY return a "404 Not Found" status-line, as described in section 6.5.3 in [RFC7231]. All other error responses are handled according to the procedures defined in Section 7.

If the target resource represents a YANG leaf-list or list, then the PATCH method SHOULD NOT delete more than one such instance. The server MAY delete more than one instance if a query parameter is used requesting this behavior. (Definition of this query parameter is outside the scope of this document.)

Example:

To delete a resource such as the "album" resource, the client might send:

```
DELETE /restconf/data/example-jukebox:jukebox/
    library/artist=Foo%20Fighters/album=Wasting%20Light HTTP/1.1
Host: example.com
```

If the resource is deleted, the server might respond:

```
HTTP/1.1 204 No Content
Date: Mon, 23 Apr 2012 17:49:40 GMT
Server: example-server
```

4.8. Query Parameters

Each RESTCONF operation allows zero or more query parameters to be present in the request URI. The specific parameters that are allowed depends on the resource type, and sometimes the specific target resource used, in the request.

- Query parameters can be given in any order.
- Each parameter can appear at most once in a request URI.
- A default value may apply if the parameter is missing.
- Query parameter names and values are case-sensitive
- A server MUST return an error with a '400 Bad Request' status-line if a query parameter is unexpected.

Name	Methods	Description

content	GET	Select config and/or non-config data resources
depth	GET	Request limited sub-tree depth in the reply content
fields	GET	Request a subset of the target resource contents
filter	GET	Boolean notification filter for event stream resources
insert	POST, PUT	Insertion mode for ordered-by user data resources
point	POST, PUT	Insertion point for ordered-yb user data resources
start-time	GET	Replay buffer start time for event stream resources
stop-time	GET	Replay buffer stop time for event stream resources
with-defaults	GET	Control retrieval of default values

RESTCONF Query Parameters

Refer to Appendix D.3 for examples of query parameter usage.

If vendors define additional query parameters, they SHOULD use a prefix (such as the enterprise or organization name) for query parameter names in order to avoid collisions with other parameters.

4.8.1. The "content" Query Parameter

The "content" parameter controls how descendant nodes of the requested data nodes will be processed in the reply.

The allowed values are:

Value	Description
config	Return only configuration descendant data nodes
nonconfig	Return only non-configuration descendant data nodes
all	Return all descendant data nodes

This parameter is only allowed for GET methods on datastore and data resources. A "400 Bad Request" status-line is returned if used for other methods or resource types.

If this query parameter is not present, the default value is "all". This query parameter MUST be supported by the server.

4.8.2. The "depth" Query Parameter

The "depth" parameter is used to specify the number of nest levels returned in a response for a GET method. The first nest-level consists of the requested data node itself. If the "fields" parameter (Section 4.8.3) is used to select descendant data nodes, these nodes all have a depth value of 1. This has the effect of including the nodes specified by the fields, even if the "depth" value is less than the actual depth level of the specified fields. Any child nodes which are contained within a parent node have a depth value that is 1 greater than its parent.

The value of the "depth" parameter is either an integer between 1 and 65535, or the string "unbounded". "unbounded" is the default.

This parameter is only allowed for GET methods on API, datastore, and data resources. A "400 Bad Request" status-line is returned if it used for other methods or resource types.

More than one "depth" query parameter MUST NOT appear in a request. If more than one instance is present, then a "400 Bad Request" status-line MUST be returned by the server.

By default, the server will include all sub-resources within a retrieved resource, which have the same resource type as the requested resource. Only one level of sub-resources with a different media type than the target resource will be returned. The exception is the datastore resource. If this resource type is retrieved then by default the datastore and all child data resources are returned.

If the "depth" query parameter URI is listed in the "capability" leaf-list in Section 9.3, then the server supports the "depth" query parameter.

4.8.3. The "fields" Query Parameter

The "fields" query parameter is used to optionally identify data nodes within the target resource to be retrieved in a GET method. The client can use this parameter to retrieve a subset of all nodes in a resource.

A value of the "fields" query parameter matches the following rule:

```
fields-expr = path '(' fields-expr ')' /
              path ';' fields-expr /
```

```
               path
path = api-identifier [ '/' path ]
```

"api-identifier" is defined in Section 3.5.1.1.

";" is used to select multiple nodes. For example, to retrieve only the "genre" and "year" of an album, use: "fields=genre;year".

Parentheses are used to specify sub-selectors of a node.

For example, assume the target resource is the "album" list. To retrieve only the "label" and "catalogue-number" of the "admin" container within an album, use: "fields=admin(label;catalogue-number)".

"/" is used in a path to retrieve a child node of a node. For example, to retrieve only the "label" of an album, use: "fields=admin/label".

This parameter is only allowed for GET methods on api, datastore, and data resources. A "400 Bad Request" status-line is returned if used for other methods or resource types.

More than one "fields" query parameter MUST NOT appear in a request. If more than one instance is present, then a "400 Bad Request" status-line MUST be returned by the server.

If the "fields" query parameter URI is listed in the "capability" leaf-list in Section 9.3, then the server supports the "fields" parameter.

4.8.4. The "filter" Query Parameter

The "filter" parameter is used to indicate which subset of all possible events are of interest. If not present, all events not precluded by other parameters will be sent.

This parameter is only allowed for GET methods on a text/event-stream data resource. A "400 Bad Request" status-line is returned if used for other methods or resource types.

The format of this parameter is an XPath 1.0 expression, and is evaluated in the following context:

- The set of namespace declarations is the set of prefix and namespace pairs for all supported YANG modules, where the prefix is the YANG module name, and the namespace is as defined by the "namespace" statement in the YANG module.

- The function library is the core function library defined in XPath 1.0.
- The set of variable bindings is empty.
- The context node is the root node.

More than one "filter" query parameter MUST NOT appear in a request. If more than one instance is present, then a "400 Bad Request" status-line MUST be returned by the server.

The filter is used as defined in [RFC5277], Section 3.6. If the boolean result of the expression is true when applied to the conceptual "notification" document root, then the event notification is delivered to the client.

If the "filter" query parameter URI is listed in the "capability" leaf-list in Section 9.3, then the server supports the "filter" query parameter.

4.8.5. The "insert" Query Parameter

The "insert" parameter is used to specify how a resource should be inserted within a ordered-by user list.

The allowed values are:

Value	Description
first	Insert the new data as the new first entry.
last	Insert the new data as the new last entry.
before	Insert the new data before the insertion point, as specified by the value of the "point" parameter.
after	Insert the new data after the insertion point, as specified by the value of the "point" parameter.

The default value is "last".

This parameter is only supported for the POST and PUT methods. It is also only supported if the target resource is a data resource, and that data represents a YANG list or leaf-list that is ordered-by user.

More than one "insert" query parameter MUST NOT appear in a request. If more than one instance is present, then a "400 Bad Request" status-line MUST be returned by the server.

If the values "before" or "after" are used, then a "point" query parameter for the insertion parameter MUST also be present, or a "400 Bad Request" status-line is returned.

The "insert" query parameter MUST be supported by the server.

4.8.6. The "point" Query Parameter

The "point" parameter is used to specify the insertion point for a data resource that is being created or moved within an ordered-by user list or leaf-list.

The value of the "point" parameter is a string that identifies the path to the insertion point object. The format is the same as a target resource URI string.

This parameter is only supported for the POST and PUT methods. It is also only supported if the target resource is a data resource, and that data represents a YANG list or leaf-list that is ordered-by user.

If the "insert" query parameter is not present, or has a value other than "before" or "after", then a "400 Bad Request" status-line is returned.

More than one "point" query parameter MUST NOT appear in a request. If more than one instance is present, then a "400 Bad Request" status-line MUST be returned by the server.

This parameter contains the instance identifier of the resource to be used as the insertion point for a POST or PUT method.

The "point" query parameter MUST be supported by the server.

4.8.7. The "start-time" Query Parameter

The "start-time" parameter is used to trigger the notification replay feature and indicate that the replay should start at the time specified. If the stream does not support replay, per the "replay-support" attribute returned by stream list entry for the stream resource, then the server MUST return a "400 Bad Request" status-line.

The value of the "start-time" parameter is of type "date-and-time", defined in the "ietf-yang" YANG module [RFC6991].

This parameter is only allowed for GET methods on a text/event-stream data resource. A "400 Bad Request" status-line is returned if used for other methods or resource types.

More than one "start-time" query parameter MUST NOT appear in a request. If more than one instance is present, then a "400 Bad Request" status-line MUST be returned by the server.

If this parameter is not present, then a replay subscription is not being requested. It is not valid to specify start times that are later than the current time. If the value specified is earlier than the log can support, the replay will begin with the earliest available notification.

If this query parameter is supported by the server, then the "replay" query parameter URI MUST be listed in the "capability" leaf-list in Section 9.3. The "stop-time" query parameter MUST also be supported by the server.

If the "replay-support" leaf has the value 'true' in the "stream" entry (defined in Section 9.3) then the server MUST support the "start-time" and "stop-time" query parameters for that stream.

4.8.8. The "stop-time" Query Parameter

The "stop-time" parameter is used with the replay feature to indicate the newest notifications of interest. This parameter MUST be used with and have a value later than the "start-time" parameter.

The value of the "stop-time" parameter is of type "date-and-time", defined in the "ietf-yang" YANG module [RFC6991].

This parameter is only allowed for GET methods on a text/event-stream data resource. A "400 Bad Request" status-line is returned if used for other methods or resource types.

More than one "stop-time" query parameter MUST NOT appear in a request. If more than one instance is present, then a "400 Bad Request" status-line MUST be returned by the server.

If this parameter is not present, the notifications will continue until the subscription is terminated. Values in the future are valid.

If this query parameter is supported by the server, then the "replay" query parameter URI MUST be listed in the "capability" leaf-list in Section 9.3. The "start-time" query parameter MUST also be supported by the server.

If the "replay-support" leaf is present in the "stream" entry (defined in Section 9.3) then the server MUST support the "start-time" and "stop-time" query parameters for that stream.

4.8.9. The "with-defaults" Query Parameter

The "with-defaults" parameter is used to specify how information about default data nodes should be returned in response to GET requests on data resources.

If the server supports this capability, then it MUST implement the behavior in Section 4.5.1 of [RFC6243], except applied to the RESTCONF GET operation, instead of the NETCONF operations.

Value	Description
report-all	All data nodes are reported
trim	Data nodes set to the YANG default are not reported
explicit	Data nodes set to the YANG default by the client are reported
report-all-tagged	All data nodes are reported and defaults are tagged

If the "with-defaults" parameter is set to "report-all" then the server MUST adhere to the defaults reporting behavior defined in Section 3.1 of [RFC6243].

If the "with-defaults" parameter is set to "trim" then the server MUST adhere to the defaults reporting behavior defined in Section 3.2 of [RFC6243].

If the "with-defaults" parameter is set to "explicit" then the server MUST adhere to the defaults reporting behavior defined in Section 3.3 of [RFC6243].

If the "with-defaults" parameter is set to "report-all-tagged" then the server MUST adhere to the defaults reporting behavior defined in Section 3.4 of [RFC6243].

More than one "with-defaults" query parameter MUST NOT appear in a request. If more than one instance is present, then a "400 Bad Request" status-line MUST be returned by the server.

If the "with-defaults" parameter is not present then the server MUST adhere to the defaults reporting behavior defined in its "basic-mode"

parameter for the "defaults" protocol capability URI, defined in Section 9.1.2.

If the server includes the "with-defaults" query parameter URI in the "capability" leaf-list in Section 9.3, then the "with-defaults" query parameter MUST be supported.

5. Messages

The RESTCONF protocol uses HTTP entities for messages. A single HTTP message corresponds to a single protocol method. Most messages can perform a single task on a single resource, such as retrieving a resource or editing a resource. The exception is the PATCH method, which allows multiple datastore edits within a single message.

5.1. Request URI Structure

Resources are represented with URIs following the structure for generic URIs in [RFC3986].

A RESTCONF operation is derived from the HTTP method and the request URI, using the following conceptual fields:

```
  <OP> /<restconf>/<path>?<query>#<fragment>

     ^       ^        ^       ^         ^
     |       |        |       |         |
   method  entry  resource  query    fragment

     M       M        O        O         I

   M=mandatory, O=optional, I=ignored
```

where:

<OP> is the HTTP method
<restconf> is the RESTCONF entry point
<path> is the Target Resource URI
<query> is the query parameter list
<fragment> is not used in RESTCONF

o method: the HTTP method identifying the RESTCONF operation requested by the client, to act upon the target resource specified in the request URI. RESTCONF operation details are described in Section 4.

- entry: the root of the RESTCONF API configured on this HTTP server, discovered by getting the "/.well-known/host-meta" resource, as described in Section 3.1.

- resource: the path expression identifying the resource that is being accessed by the operation. If this field is not present, then the target resource is the API itself, represented by the media type "application/yang.api".

- query: the set of parameters associated with the RESTCONF message. These have the familiar form of "name=value" pairs. Most query parameters are optional to implement by the server and optional to use by the client. Each optional query parameter is identified by a URI. The server MUST list the optional query parameter URIs it supports in the "capabilities" list defined in Section 9.3.

There is a specific set of parameters defined, although the server MAY choose to support query parameters not defined in this document. The contents of the any query parameter value MUST be encoded according to [RFC3986], Section 3.4. Any reserved characters MUST be percent-encoded, according to [RFC3986], section 2.1.

- fragment: This field is not used by the RESTCONF protocol.

When new resources are created by the client, a "Location" header is returned, which identifies the path of the newly created resource. The client uses this exact path identifier to access the resource once it has been created.

The "target" of an operation is a resource. The "path" field in the request URI represents the target resource for the operation.

Refer to Appendix D for examples of RESTCONF Request URIs.

5.2. Message Encoding

RESTCONF messages are encoded in HTTP according to [RFC7230]. The "utf-8" character set is used for all messages. RESTCONF message content is sent in the HTTP message-body.

Content is encoded in either JSON or XML format. A server MUST support XML or JSON encoding. XML encoding rules for data nodes are defined in [I-D.ietf-netmod-rfc6020bis]. The same encoding rules are used for all XML content. JSON encoding rules are defined in [I-D.ietf-netmod-yang-json]. JSON encoding of meta-data is defined in [I-D.ietf-netmod-yang-metadata]. This encoding is valid JSON, but also has special encoding rules to identify module namespaces and provide consistent type processing of YANG data.

Request input content encoding format is identified with the Content-Type header. This field MUST be present if a message-body is sent by the client.

The server MUST support the "Accept" header and "406 Not Acceptable" status-line, as defined in [RFC7231]. Response output content encoding format is identified with the Accept header in the request. If it is not specified, the request input encoding format SHOULD be used, or the server MAY choose any supported content encoding format.

If there was no request input, then the default output encoding is XML or JSON, depending on server preference. File extensions encoded in the request are not used to identify format encoding.

5.3. RESTCONF Meta-Data

The RESTCONF protocol needs to retrieve the same meta-data that is used in the NETCONF protocol. Information about default leafs, last-modified timestamps, etc. are commonly used to annotate representations of the datastore contents. This meta-data is not defined in the YANG schema because it applies to the datastore, and is common across all data nodes.

This information is encoded as attributes in XML. JSON encoding of meta-data is defined in [I-D.ietf-netmod-yang-metadata].

The following examples are based on the example in Appendix D.3.9. The "report-all-tagged" mode for the "with-defaults" query parameter requires that a "default" attribute be returned for default nodes. This example shows that attribute for the "mtu" leaf .

5.3.1. XML MetaData Encoding Example

```
GET /restconf/data/interfaces/interface=eth1
    ?with-defaults=report-all-tagged HTTP/1.1
Host: example.com
Accept: application/yang.data+xml
```

The server might respond as follows.

```
HTTP/1.1 200 OK
Date: Mon, 23 Apr 2012 17:01:00 GMT
Server: example-server
Content-Type: application/yang.data+xml

<interface
  xmlns="urn:example.com:params:xml:ns:yang:example-interface">
  <name>eth1</name>
```

```
  <mtu xmlns:wd="urn:ietf:params:xml:ns:netconf:default:1.0"
    wd:default="true">1500</mtu>
  <status>up</status>
</interface>
```

5.3.2. JSON MetaData Encoding Example

Note that RFC 6243 defines the "default" attribute with XSD, not YANG, so the YANG module name has to be assigned manually. The value "ietf-netconf-with-defaults" is assigned for JSON meta-data encoding.

```
GET /restconf/data/interfaces/interface=eth1
    ?with-defaults=report-all-tagged HTTP/1.1
Host: example.com
Accept: application/yang.data+json
```

The server might respond as follows.

```
   HTTP/1.1 200 OK
   Date: Mon, 23 Apr 2012 17:01:00 GMT
   Server: example-server
   Content-Type: application/yang.data+json

   {
     "example:interface": [
       {
         "name" : "eth1",
         "mtu" : 1500,
         "@mtu": {
            "ietf-netconf-with-defaults:default" : true
         },
         "status" : "up"
       }
     ]
   }
```

5.4. Return Status

Each message represents some sort of resource access. An HTTP "status-line" header line is returned for each request. If a 4xx or 5xx range status code is returned in the status-line, then the error information will be returned in the response, according to the format defined in Section 7.1.

5.5. Message Caching

Since the datastore contents change at unpredictable times, responses from a RESTCONF server generally SHOULD NOT be cached.

The server SHOULD include a "Cache-Control" header in every response that specifies whether the response should be cached. A "Pragma" header specifying "no-cache" MAY also be sent in case the "Cache-Control" header is not supported.

Instead of relying on HTTP caching, the client SHOULD track the "ETag" and/or "Last-Modified" headers returned by the server for the datastore resource (or data resource if the server supports it). A retrieval request for a resource can include the "If-None-Match" and/or "If-Modified-Since" headers, which will cause the server to return a "304 Not Modified" status-line if the resource has not changed. The client MAY use the HEAD method to retrieve just the message headers, which SHOULD include the "ETag" and "Last-Modified" headers, if this meta-data is maintained for the target resource.

6. Notifications

The RESTCONF protocol supports YANG-defined event notifications. The solution preserves aspects of NETCONF Event Notifications [RFC5277] while utilizing the Server-Sent Events [W3C.CR-eventsource-20121211] transport strategy.

6.1. Server Support

A RESTCONF server MAY support RESTCONF notifications. Clients may determine if a server supports RESTCONF notifications by using the HTTP operation OPTIONS, HEAD, or GET on the stream list. The server does not support RESTCONF notifications if an HTTP error code is returned (e.g., "404 Not Found" status-line).

6.2. Event Streams

A RESTCONF server that supports notifications will populate a stream resource for each notification delivery service access point. A RESTCONF client can retrieve the list of supported event streams from a RESTCONF server using the GET operation on the stream list.

The "restconf-state/streams" container definition in the "ietf-restconf-monitoring" module (defined in Section 9.3) is used to specify the structure and syntax of the conceptual child resources within the "streams" resource.

For example:

The client might send the following request:

```
GET /restconf/data/ietf-restconf-monitoring:restconf-state/
    streams HTTP/1.1
```

```
   Host: example.com
   Accept: application/yang.data+xml

   The server might send the following response:

   HTTP/1.1 200 OK
   Content-Type: application/yang.api+xml

   <streams
     xmlns="urn:ietf:params:xml:ns:yang:ietf-restconf-monitoring">
      <stream>
         <name>NETCONF</name>
         <description>default NETCONF event stream
         </description>
         <replay-support>true</replay-support>
         <replay-log-creation-time>
            2007-07-08T00:00:00Z
         </replay-log-creation-time>
         <access>
            <encoding>xml</encoding>
            <location>https://example.com/streams/NETCONF
            </location>
         </access>
         <access>
            <encoding>json</encoding>
            <location>https://example.com/streams/NETCONF-JSON
            </location>
         </access>
      </stream>
      <stream>
         <name>SNMP</name>
         <description>SNMP notifications</description>
         <replay-support>false</replay-support>
         <access>
            <encoding>xml</encoding>
            <location>https://example.com/streams/SNMP</location>
         </access>
      </stream>
      <stream>
         <name>syslog-critical</name>
         <description>Critical and higher severity
         </description>
         <replay-support>true</replay-support>
         <replay-log-creation-time>
            2007-07-01T00:00:00Z
         </replay-log-creation-time>
         <access>
            <encoding>xml</encoding>
```

```
          <location>
            https://example.com/streams/syslog-critical
          </location>
        </access>
      </stream>
    </streams>
```

6.3. Subscribing to Receive Notifications

RESTCONF clients can determine the URL for the subscription resource (to receive notifications) by sending an HTTP GET request for the "location" leaf with the stream list entry. The value returned by the server can be used for the actual notification subscription.

The client will send an HTTP GET request for the URL returned by the server with the "Accept" type "text/event-stream".

The server will treat the connection as an event stream, using the Server Sent Events [W3C.CR-eventsource-20121211] transport strategy.

The server MAY support query parameters for a GET method on this resource. These parameters are specific to each notification stream.

For example:

The client might send the following request:

```
GET /restconf/data/ietf-restconf-monitoring:restconf-state/
    streams/stream=NETCONF/access=xml/location HTTP/1.1
Host: example.com
Accept: application/yang.data+xml
```

The server might send the following response:

```
HTTP/1.1 200 OK
Content-Type: application/yang.api+xml

<location
  xmlns="urn:ietf:params:xml:ns:yang:ietf-restconf-monitoring">
  https://example.com/streams/NETCONF
</location>
```

The RESTCONF client can then use this URL value to start monitoring the event stream:

```
GET /streams/NETCONF HTTP/1.1
Host: example.com
Accept: text/event-stream
```

```
Cache-Control: no-cache
Connection: keep-alive
```

A RESTCONF client MAY request the server compress the events using the HTTP header field "Accept-Encoding". For instance:

```
GET /streams/NETCONF HTTP/1.1
Host: example.com
Accept: text/event-stream
Cache-Control: no-cache
Connection: keep-alive
Accept-Encoding: gzip, deflate
```

6.3.1. NETCONF Event Stream

The server SHOULD support the "NETCONF" notification stream defined in [RFC5277]. For this stream, RESTCONF notification subscription requests MAY specify parameters indicating the events it wishes to receive. These query parameters are optional to implement, and only available if the server supports them.

Name	Section	Description
start-time	4.8.7	replay event start time
stop-time	4.8.8	replay event stop time
filter	4.8.4	boolean content filter

NETCONF Stream Query Parameters

The semantics and syntax for these query parameters are defined in the sections listed above. The YANG definition MUST be converted to a URI-encoded string for use in the request URI.

Refer to Appendix D.3.6 for filter parameter examples.

6.4. Receiving Event Notifications

RESTCONF notifications are encoded according to the definition of the event stream. The NETCONF stream defined in [RFC5277] is encoded in XML format.

The structure of the event data is based on the "notification" element definition in Section 4 of [RFC5277]. It MUST conform to the schema for the "notification" element in Section 4 of [RFC5277], except the XML namespace for this element is defined as:

urn:ietf:params:xml:ns:yang:ietf-restconf

For JSON encoding purposes, the module name for the "notification" element is "ietf-restconf".

Two child nodes within the "notification" container are expected, representing the event time and the event payload. The "event-time" node is defined within the "ietf-restconf" module namespace. The name and namespace of the payload element are determined by the YANG module containing the notification-stmt.

In the following example, the YANG module "example-mod" is used:

```
  module example-mod {
    namespace "http://example.com/event/1.0";
    prefix ex;

    notification event {
     leaf event-class { type string; }
     container reporting-entity {
       leaf card { type string; }
     }
     leaf severity { type string; }
    }
  }
```

An example SSE event notification encoded using XML:

```
data: <notification
data:    xmlns="urn:ietf:params:xml:ns:yang:ietf-restconf">
data:    <event-time>2013-12-21T00:01:00Z</event-time>
data:    <event xmlns="http://example.com/event/1.0">
data:       <event-class>fault</event-class>
data:       <reporting-entity>
data:           <card>Ethernet0</card>
data:       </reporting-entity>
data:       <severity>major</severity>
data:     </event>
data: </notification>
```

An example SSE event notification encoded using JSON:

```
data: {
data:   "ietf-restconf:notification": {
data:     "event-time": "2013-12-21T00:01:00Z",
data:     "example-mod:event": {
data:       "event-class": "fault",
data:       "reporting-entity": { "card": "Ethernet0" },
```

```
data:       "severity": "major"
data:     }
data:   }
data: }
```

Alternatively, since neither XML nor JSON are whitespace sensitive, the above messages can be encoded onto a single line. For example:

For example: ('\' line wrapping added for formatting only)

XML:

```
data: <notification xmlns="urn:ietf:params:xml:ns:yang:ietf-rest\
conf"><event-time>2013-12-21T00:01:00Z</event-time><event xmlns="\
http://example.com/event/1.0"><event-class>fault</event-class><re\
portingEntity><card>Ethernet0</card></reporting-entity><severity>\
major</severity></event></notification>
```

JSON:

```
data: {"ietf-restconf:notification":{"event-time":"2013-12-21\
T00:01:00Z","example-mod:event":{"event-class": "fault","repor\
tingEntity":{"card":"Ethernet0"},"severity":"major"}}}
```

The SSE specifications supports the following additional fields: event, id and retry. A RESTCONF server MAY send the "retry" field and, if it does, RESTCONF clients SHOULD use it. A RESTCONF server SHOULD NOT send the "event" or "id" fields, as there are no meaningful values that could be used for them that would not be redundant to the contents of the notification itself. RESTCONF servers that do not send the "id" field also do not need to support the HTTP header "Last-Event-Id". RESTCONF servers that do send the "id" field MUST still support the "startTime" query parameter as the preferred means for a client to specify where to restart the event stream.

7. Error Reporting

HTTP status-lines are used to report success or failure for RESTCONF operations. The <rpc-error> element returned in NETCONF error responses contains some useful information. This error information is adapted for use in RESTCONF, and error information is returned for "4xx" class of status codes.

The following table summarizes the return status codes used specifically by RESTCONF operations:

Status-Line	Description
100 Continue	POST accepted, 201 should follow
200 OK	Success with response message-body
201 Created	POST to create a resource success
204 No Content	Success without response message-body
304 Not Modified	Conditional operation not done
400 Bad Request	Invalid request message
401 Unauthorized	Client cannot be authenticated
403 Forbidden	Access to resource denied
404 Not Found	Resource target or resource node not found
405 Method Not Allowed	Method not allowed for target resource
409 Conflict	Resource or lock in use
412 Precondition Failed	Conditional method is false
413 Request Entity Too Large	too-big error
414 Request-URI Too Large	too-big error
415 Unsupported Media Type	non RESTCONF media type
500 Internal Server Error	operation-failed
501 Not Implemented	unknown-operation
503 Service Unavailable	Recoverable server error

HTTP Status Codes used in RESTCONF

Since an operation resource is defined with a YANG "rpc" statement, and an action is defined with a YANG "action" statement, a mapping between the NETCONF <error-tag> value and the HTTP status code is needed. The specific error condition and response code to use are data-model specific and might be contained in the YANG "description" statement for the "action" or "rpc" statement.

<error‑tag>	status code
in-use	409
invalid-value	400
too-big	413
missing-attribute	400
bad-attribute	400
unknown-attribute	400
bad-element	400
unknown-element	400
unknown-namespace	400

access-denied	403
lock-denied	409
resource-denied	409
rollback-failed	500
data-exists	409
data-missing	409
operation-not-supported	501
operation-failed	500
partial-operation	500
malformed-message	400

Mapping from error-tag to status code

7.1. Error Response Message

When an error occurs for a request message on any resource type, and a "4xx" class of status codes will be returned (except for status code "403 Forbidden"), then the server SHOULD send a response message-body containing the information described by the "errors" container definition within the YANG module Section 8. The Content-Type of this response message MUST be a subtype of application/yang.errors (see example below).

The client SHOULD specify the desired encoding for error messages by specifying the appropriate media-type in the Accept header. If no error media is specified, then the media subtype (e.g., XML or JSON) of the request message SHOULD be used, or the server MAY choose any supported message encoding format. If there is no request message the server MUST select "application/yang.errors+xml" or "application/yang.errors+json", depending on server preference. All of the examples in this document, except for the one below, assume that XML encoding will be returned if there is an error.

YANG Tree Diagram for <errors> data:

```
+--ro errors
   +--ro error*
      +--ro error-type       enumeration
      +--ro error-tag        string
      +--ro error-app-tag?   string
      +--ro error-path?      instance-identifier
      +--ro error-message?   string
      +--ro error-info
```

The semantics and syntax for RESTCONF error messages are defined in the "application/yang.errors" restconf-media-type extension in Section 8.

Examples:

The following example shows an error returned for an "lock-denied" error that can occur if a NETCONF client has locked a datastore. The RESTCONF client is attempting to delete a data resource. Note that an Accept header is used to specify the desired encoding for the error message. No response message-body content is expected by the client in this example.

```
DELETE /restconf/data/example-jukebox:jukebox/
   library/artist=Foo%20Fighters/album=Wasting%20Light HTTP/1.1
Host: example.com
Accept: application/yang.errors+json
```

The server might respond:

```
   HTTP/1.1 409 Conflict
   Date: Mon, 23 Apr 2012 17:11:00 GMT
   Server: example-server
   Content-Type: application/yang.errors+json

   {
     "ietf-restconf:errors": {
       "error": [
         {
           "error-type": "protocol",
           "error-tag": "lock-denied",
           "error-message": "Lock failed, lock already held"
         }
       ]
     }
   }
```

The following example shows an error returned for a "data-exists" error on a data resource. The "jukebox" resource already exists so it cannot be created.

The client might send:

```
POST /restconf/data/example-jukebox:jukebox HTTP/1.1
Host: example.com
```

The server might respond (some lines wrapped for display purposes):

```
HTTP/1.1 409 Conflict
Date: Mon, 23 Apr 2012 17:11:00 GMT
Server: example-server
Content-Type: application/yang.errors+xml
```

```
<errors xmlns="urn:ietf:params:xml:ns:yang:ietf-restconf">
  <error>
    <error-type>protocol</error-type>
    <error-tag>data-exists</error-tag>
    <error-path
      xmlns:rc="urn:ietf:params:xml:ns:yang:ietf-restconf"
      xmlns:jbox="https://example.com/ns/example-jukebox">
      /rc:restconf/rc:data/jbox:jukebox
    </error-path>
    <error-message>
      Data already exists, cannot create new resource
    </error-message>
  </error>
</errors>
```

8. RESTCONF module

The "ietf-restconf" module defines conceptual definitions within an extension and two groupings, which are not meant to be implemented as datastore contents by a server. E.g., the "restconf" container is not intended to be implemented as a top-level data node (under the "/restconf/data" entry point).

RFC Ed.: update the date below with the date of RFC publication and remove this note.

<CODE BEGINS> file "ietf-restconf@2016-03-16.yang"

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

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

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

     WG Chair: Mehmet Ersue
               <mailto:mehmet.ersue@nsn.com>

     WG Chair: Mahesh Jethanandani
               <mailto:mjethanandani@gmail.com>

     Editor:   Andy Bierman
               <mailto:andy@yumaworks.com>
```

```
        Editor:   Martin Bjorklund
                  <mailto:mbj@tail-f.com>

        Editor:   Kent Watsen
                  <mailto:kwatsen@juniper.net>";

     description
       "This module contains conceptual YANG specifications
        for basic RESTCONF media type definitions used in
        RESTCONF protocol messages.

        Note that the YANG definitions within this module do not
        represent configuration data of any kind.
        The 'restconf-media-type' YANG extension statement
        provides a normative syntax for XML and JSON message
        encoding purposes.

        Copyright (c) 2016 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.";

     // RFC Ed.: replace XXXX with actual RFC number and remove this
     // note.

     // RFC Ed.: remove this note
     // Note: extracted from draft-ietf-netconf-restconf-12.txt

     // RFC Ed.: update the date below with the date of RFC publication
     // and remove this note.
     revision 2016-03-16 {
       description
         "Initial revision.";
       reference
         "RFC XXXX: RESTCONF Protocol.";
     }

     extension restconf-media-type {
      argument media-type-id {
        yin-element true;
```

```
      }
      // RFC Ed.: replace draft-ietf-netmod-yang-json with RFC number
      // in the description below, and remove this note.
      description
        "This extension is used to specify a YANG data structure which
         represents a conceptual RESTCONF media type.
         Data definition statements within this extension specify
         the generic syntax for the specific media type.

         YANG is mapped to specific encoding formats outside the
         scope of this extension statement. RFC 6020 defines XML
         encoding rules for all RESTCONF media types that use
         the '+xml' suffix. draft-ietf-netmod-yang-json defines
         JSON encoding rules for all RESTCONF media types that
         use the '+json' suffix.

         The 'media-type-id' parameter value identifies the media type
         that is being defined. It contains the string associated
         with the generic media type, i.e., no suffix is specified.

         This extension is ignored unless it appears as a top-level
         statement. It SHOULD contain data definition statements
         that result in exactly one container data node definition.
         This allows compliant translation to an XML instance
         document for each media type.

         The module name and namespace value for the YANG module using
         the extension statement is assigned to instance document data
         conforming to the data definition statements within
         this extension.

         The sub-statements of this extension MUST follow the
         'data-def-stmt' rule in the YANG ABNF.

         The XPath document root is the extension statement itself,
         such that the child nodes of the document root are
         represented by the data-def-stmt sub-statements within
         this extension. This conceptual document is the context
         for the following YANG statements:

            - must-stmt
            - when-stmt
            - path-stmt
            - min-elements-stmt
            - max-elements-stmt
            - mandatory-stmt
            - unique-stmt
            - ordered-by
```

```
           - instance-identifier data type

        The following data-def-stmt sub-statements have special
        meaning when used within a restconf-resource extension
        statement.

        - The list-stmt is not required to have a key-stmt defined.
        - The if-feature-stmt is ignored if present.
        - The config-stmt is ignored if present.
        - The available identity values for any 'identityref'
          leaf or leaf-list nodes is limited to the module
          containing this extension statement, and the modules
          imported into that module.
        ";
    }

    rc:restconf-media-type "application/yang.errors" {
      uses errors;
    }

    rc:restconf-media-type "application/yang.api" {
      uses restconf;
    }

    grouping errors {
      description
        "A grouping that contains a YANG container
         representing the syntax and semantics of a
         YANG Patch errors report within a response message.";

      container errors {
        description
          "Represents an error report returned by the server if
           a request results in an error.";

        list error {
          description
            "An entry containing information about one
             specific error that occurred while processing
             a RESTCONF request.";
          reference "RFC 6241, Section 4.3";

          leaf error-type {
            type enumeration {
              enum transport {
                description "The transport layer";
              }
              enum rpc {
```

```
              description "The rpc or notification layer";
            }
            enum protocol {
              description "The protocol operation layer";
            }
            enum application {
              description "The server application layer";
            }
          }
          mandatory true;
          description
            "The protocol layer where the error occurred.";
        }

        leaf error-tag {
          type string;
          mandatory true;
          description
            "The enumerated error tag.";
        }

        leaf error-app-tag {
          type string;
          description
            "The application-specific error tag.";
        }

        leaf error-path {
          type instance-identifier;
          description
            "The YANG instance identifier associated
             with the error node.";
        }

        leaf error-message {
          type string;
          description
            "A message describing the error.";
        }

        anydata error-info {
           description
             "This anydata value MUST represent a container with
             zero or more data nodes representing additional
             error information.";
        }
      }
    }
```

```
    }

    grouping restconf {
      description
        "Conceptual container representing the
         application/yang.api resource type.";

      container restconf {
        description
          "Conceptual container representing the
           application/yang.api resource type.";

        container data {
          description
            "Container representing the application/yang.datastore
             resource type. Represents the conceptual root of all
             state data and configuration data supported by
             the server.  The child nodes of this container can be
             any data resource (application/yang.data), which are
             defined as top-level data nodes from the YANG modules
             advertised by the server in the ietf-restconf-monitoring
             module.";
        }

        container operations {
          description
            "Container for all operation resources
             (application/yang.operation),

             Each resource is represented as an empty leaf with the
             name of the RPC operation from the YANG rpc statement.

             E.g.;

                POST /restconf/operations/show-log-errors

                leaf show-log-errors {
                  type empty;
                }
            ";
        }

        leaf yang-library-version {
          type string {
            pattern '\d{4}-\d{2}-\d{2}';
          }
          config false;
          mandatory true;
```

```
          description
            "Identifies the revision date of the ietf-yang-library
             module that is implemented by this RESTCONF server.
             Indicates the year, month, and day in YYYY-MM-DD
             numeric format.";
        }
      }
    }

}
```

<CODE ENDS>

9. RESTCONF Monitoring

The "ietf-restconf-monitoring" module provides information about the RESTCONF protocol capabilities and event notification streams available from the server. A RESTCONF server MUST implement the "/restconf-state/capabilities" container in this module.

YANG Tree Diagram for "ietf-restconf-monitoring" module:

```
+--ro restconf-state
   +--ro capabilities
   |  +--ro capability*   inet:uri
   +--ro streams
      +--ro stream* [name]
         +--ro name                        string
         +--ro description?                string
         +--ro replay-support?             boolean
         +--ro replay-log-creation-time?   yang:date-and-time
         +--ro access* [encoding]
            +--ro encoding  string
            +--ro location  inet:uri
```

9.1. restconf-state/capabilities

This mandatory container holds the RESTCONF protocol capability URIs supported by the server.

The server MUST maintain a last-modified timestamp for this container, and return the "Last-Modified" header when this data node is retrieved with the GET or HEAD methods.

The server SHOULD maintain an entity-tag for this container, and return the "ETag" header when this data node is retrieved with the GET or HEAD methods.

The server MUST include a "capability" URI leaf-list entry for the "defaults" mode used by the server, defined in Section 9.1.2.

The server MUST include a "capability" URI leaf-list entry identifying each supported optional protocol feature. This includes optional query parameters and MAY include other capability URIs defined outside this document.

9.1.1. Query Parameter URIs

A new set of RESTCONF Capability URIs are defined to identify the specific query parameters (defined in Section 4.8) supported by the server.

The server MUST include a "capability" leaf-list entry for each optional query parameter that it supports.

Name	Section	URI
depth	4.8.2	urn:ietf:params:restconf:capability:depth:1.0
fields	4.8.3	urn:ietf:params:restconf:capability:fields:1.0
filter	4.8.4	urn:ietf:params:restconf:capability:filter:1.0
replay	4.8.7 4.8.8	urn:ietf:params:restconf:capability:replay:1.0
with-defaults	4.8.9	urn:ietf:params:restconf:capability:with-defaults:1.0

RESTCONF Query Parameter URIs

9.1.2. The "defaults" Protocol Capability URI

This URI identifies the defaults handling mode that is used by the server for processing default leafs in requests for data resources. A parameter named "basic-mode" is required for this capability URI. The "basic-mode" definitions are specified in the "With-Defaults Capability for NETCONF" [RFC6243].

Name	URI
defaults	urn:ietf:params:restconf:capability:defaults:1.0

RESTCONF defaults capability URI

This protocol capability URI MUST be supported by the server, and MUST be listed in the "capability" leaf-list in Section 9.3.

Value	Description
report-all	No data nodes are considered default
trim	Values set to the YANG default-stmt value are default
explicit	Values set by the client are never considered default

If the "basic-mode" is set to "report-all" then the server MUST adhere to the defaults handling behavior defined in Section 2.1 of [RFC6243].

If the "basic-mode" is set to "trim" then the server MUST adhere to the defaults handling behavior defined in Section 2.2 of [RFC6243].

If the "basic-mode" is set to "explicit" then the server MUST adhere to the defaults handling behavior defined in Section 2.3 of [RFC6243].

Example: (split for display purposes only)

```
urn:ietf:params:restconf:capability:defaults:1.0?
     basic-mode=explicit
```

9.2. restconf-state/streams

This optional container provides access to the event notification streams supported by the server. The server MAY omit this container if no event notification streams are supported.

The server will populate this container with a stream list entry for each stream type it supports. Each stream contains a leaf called "events" which contains a URI that represents an event stream resource.

Stream resources are defined in Section 3.8. Notifications are defined in Section 6.

9.3. RESTCONF Monitoring Module

The "ietf-restconf-monitoring" module defines monitoring information for the RESTCONF protocol.

The "ietf-yang-types" and "ietf-inet-types" modules from [RFC6991] are used by this module for some type definitions.

RFC Ed.: update the date below with the date of RFC publication and remove this note.

<CODE BEGINS> file "ietf-restconf-monitoring@2016-03-16.yang"

```
module ietf-restconf-monitoring {
  namespace "urn:ietf:params:xml:ns:yang:ietf-restconf-monitoring";
  prefix "rcmon";

  import ietf-yang-types { prefix yang; }
  import ietf-inet-types { prefix inet; }

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

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

     WG Chair: Mehmet Ersue
               <mailto:mehmet.ersue@nsn.com>

     WG Chair: Mahesh Jethanandani
               <mailto:mjethanandani@gmail.com>

     Editor:   Andy Bierman
               <mailto:andy@yumaworks.com>

     Editor:   Martin Bjorklund
               <mailto:mbj@tail-f.com>

     Editor:   Kent Watsen
               <mailto:kwatsen@juniper.net>";

  description
    "This module contains monitoring information for the
     RESTCONF protocol.

     Copyright (c) 2016 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.";

    // RFC Ed.: replace XXXX with actual RFC number and remove this
    // note.

    // RFC Ed.: remove this note
    // Note: extracted from draft-ietf-netconf-restconf-12.txt

    // RFC Ed.: update the date below with the date of RFC publication
    // and remove this note.
    revision 2016-03-16 {
      description
        "Initial revision.";
      reference
        "RFC XXXX: RESTCONF Protocol.";
    }

    container restconf-state {
      config false;
      description
        "Contains RESTCONF protocol monitoring information.";

      container capabilities {
        description
          "Contains a list of protocol capability URIs";

        leaf-list capability {
          type inet:uri;
          description "A RESTCONF protocol capability URI.";
        }
      }

      container streams {
        description
          "Container representing the notification event streams
           supported by the server.";
         reference
           "RFC 5277, Section 3.4, <streams> element.";

        list stream {
          key name;
```

```
          description
            "Each entry describes an event stream supported by
             the server.";

          leaf name {
            type string;
            description "The stream name";
            reference "RFC 5277, Section 3.4, <name> element.";
          }

          leaf description {
            type string;
            description "Description of stream content";
            reference
              "RFC 5277, Section 3.4, <description> element.";
          }

          leaf replay-support {
            type boolean;
            description
              "Indicates if replay buffer supported for this stream.
               If 'true', then the server MUST support the 'start-time'
               and 'stop-time' query parameters for this stream.";
            reference
              "RFC 5277, Section 3.4, <replaySupport> element.";
          }

          leaf replay-log-creation-time {
            when "../replay-support" {
              description
                "Only present if notification replay is supported";
            }
            type yang:date-and-time;
            description
              "Indicates the time the replay log for this stream
               was created.";
            reference
              "RFC 5277, Section 3.4, <replayLogCreationTime>
               element.";
          }

          list access {
            key encoding;
            min-elements 1;
            description
              "The server will create an entry in this list for each
               encoding format that is supported for this stream.
               The media type 'application/yang.stream' is expected
```

```
               for all event streams. This list identifies the
               sub-types supported for this stream.";

            leaf encoding {
              type string;
              description
                "This is the secondary encoding format within the
                 'text/event-stream' encoding used by all streams.
                 The type 'xml' is supported for the media type
                 'application/yang.stream+xml'. The type 'json'
                 is supported for the media type
                 'application/yang.stream+json'.";

            }

            leaf location {
              type inet:uri;
              mandatory true;
              description
                "Contains a URL that represents the entry point
                 for establishing notification delivery via server
                 sent events.";
            }
          }
        }
      }
    }

  }

  <CODE ENDS>
```

10. YANG Module Library

The "ietf-yang-library" module defined in [I-D.ietf-netconf-yang-library] provides information about the YANG modules and submodules used by the RESTCONF server. Implementation is mandatory for RESTCONF servers. All YANG modules and submodules used by the server MUST be identified in the YANG module library.

10.1. modules

This mandatory container holds the identifiers for the YANG data model modules supported by the server.

The server MUST maintain a last-modified timestamp for this container, and return the "Last-Modified" header when this data node is retrieved with the GET or HEAD methods.

The server SHOULD maintain an entity-tag for this container, and return the "ETag" header when this data node is retrieved with the GET or HEAD methods.

10.1.1. modules/module

This mandatory list contains one entry for each YANG data model module supported by the server. There MUST be an instance of this list for every YANG module that is used by the server.

The contents of this list are defined in the "module" YANG list statement in [I-D.ietf-netconf-yang-library].

The server SHOULD maintain a last-modified timestamp for each instance of this list entry, and return the "Last-Modified" header when this data node is retrieved with the GET or HEAD methods.

The server SHOULD maintain an entity-tag for each instance of this list entry, and return the "ETag" header when this data node is retrieved with the GET or HEAD methods.

11. IANA Considerations

11.1. The "restconf" Relation Type

This specification registers the "restconf" relation type in the Link Relation Type Registry defined by [RFC5988]:

Relation Name: restconf

Description: Identifies the root of RESTCONF API as configured on this HTTP server. The "restconf" relation defines the root of the API defined in RFCXXXX. Subsequent revisions of RESTCONF will use alternate relation values to support protocol versioning.

Reference: RFCXXXX

`

11.2. YANG Module Registry

This document registers two URIs in the IETF XML registry [RFC3688]. Following the format in RFC 3688, the following registration is requested to be made.

URI: urn:ietf:params:xml:ns:yang:ietf-restconf
Registrant Contact: The NETMOD WG of the IETF.

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

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

This document registers two YANG modules in the YANG Module Names registry [RFC6020].

```
name:         ietf-restconf
namespace:    urn:ietf:params:xml:ns:yang:ietf-restconf
prefix:       rc
// RFC Ed.: replace XXXX with RFC number and remove this note
reference:    RFCXXXX

name:         ietf-restconf-monitoring
namespace:    urn:ietf:params:xml:ns:yang:ietf-restconf-monitoring
prefix:       rcmon
// RFC Ed.: replace XXXX with RFC number and remove this note
reference:    RFCXXXX
```

11.3. application/yang Media Sub Types

The parent MIME media type for RESTCONF resources is application/yang, which is defined in [RFC6020]. This document defines the following sub-types for this media type.

- api
- data
- datastore
- errors
- operation
- stream

Type name: application

Subtype name: yang.xxx, where "xxx" is 1 of "api", "data", "datastore", "errors", "operation", or "stream"

Required parameters: none

Optional parameters: See section 4.8 in RFC XXXX

Encoding considerations: 8-bit

Security considerations: See Section 12 in RFC XXXX

Interoperability considerations: none

```
      // RFC Ed.: replace XXXX with RFC number and remove this note
      Published specification: RFC XXXX
```

11.4. RESTCONF Capability URNs

[Note to RFC Editor:
 The RESTCONF Protocol Capability Registry does not yet exist;
 Need to ask IANA to create it; remove this note for publication
]

This document defines a registry for RESTCONF capability identifiers. The name of the registry is "RESTCONF Capability URNs". The review policy for this registry is "IETF Review". The registry shall record for each entry:

- the name of the RESTCONF capability. By convention, this name is prefixed with the colon ':' character.

- the URN for the RESTCONF capability.

This document registers several capability identifiers in "RESTCONF Capability URNs" registry:

```
  Index
     Capability Identifier
  ------------------------

  :defaults
      urn:ietf:params:restconf:capability:defaults:1.0

  :depth
      urn:ietf:params:restconf:capability:depth:1.0

  :fields
      urn:ietf:params:restconf:capability:fields:1.0

  :filter
      urn:ietf:params:restconf:capability:filter:1.0

  :replay
      urn:ietf:params:restconf:capability:replay:1.0

  :with-defaults
      urn:ietf:params:restconf:capability:with-defaults:1.0
```

12. Security Considerations

This section provides security considerations for the resources defined by the RESTCONF protocol. Security considerations for HTTPS are defined in [RFC2818]. RESTCONF does not specify which YANG modules a server needs to support. Security considerations for the YANG-defined content manipulated by RESTCONF can be found in the documents defining those YANG modules.

This document does not require use of a specific client authentication mechanism or authorization model, but it does require that a client authentication mechanism and authorization model is used whenever a client accesses a protected resource. Client authentication MUST be implemented using client certificates or MUST be implemented using an HTTP authentication scheme. Client authorization MAY be configured using the NETCONF Access Control Model (NACM) [RFC6536].

Configuration information is by its very nature sensitive. Its transmission in the clear and without integrity checking leaves devices open to classic eavesdropping and false data injection attacks. Configuration information often contains passwords, user names, service descriptions, and topological information, all of which are sensitive. Because of this, this protocol SHOULD be implemented carefully with adequate attention to all manner of attack one might expect to experience with other management interfaces.

Different environments may well allow different rights prior to and then after authentication. When an operation is not properly authorized, the RESTCONF server MUST return a "401 Unauthorized" status-line. Note that authorization information can be exchanged in the form of configuration information, which is all the more reason to ensure the security of the connection.

13. Acknowledgements

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those of the author(s) and do not necessarily reflect the views of The Space & Terrestrial Communications Directorate (S&TCD).

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Appendix A. Change Log

-- RFC Ed.: remove this section before publication.

The RESTCONF issue tracker can be found here: https://github.com/netconf-wg/restconf/issues

A.1. v11 - v12

- clarify query parameter requirements
- move filter query section to match table order in sec. 4.8
- clarify that depth default is entire subtree for datastore resource
- change ietf-restconf to YANG 1.1 to use anydata instead of anyxml
- made implementation of timestamps optional since ETags are mandatory
- removed confusing text about data resource definition revision date
- clarify that errors should be returned for any resource type
- clarified media subtype (not type) for error response
- clarified client SHOULD (not MAY) specify errors format in Accept header
- clarified terminology in many sections

A.2. v10 - v11

- change term 'operational data' to 'state data'
- clarify :startup behavior
- clarify X.509 security text
- change '403 Forbidden' to '401 Unauthorized' for GET error
- clarify MUST have one "restconf" link relation

- clarify that NV-storage is not mandatory
- clarify how "Last-Modified" and "ETag" header info can be used by a client
- clarify meaning of mandatory parameter
- fix module name in action examples
- clarify operation resource request needs to be known to parse the output
- clarify ordered-by user terminology
- fixed JSON example in D.1.1

A.3. v09 - v10

- address review comments: github issue #36
- removed intro text about no knowledge of NETCONF needed
- clarified candidate and confirmed-commit behavior in sec. 1.3
- clarified that a RESTCONF server MUST support TLS
- clarified choice of 403 or 404 error
- fixed forward references to URI template (w/reference at first use)
- added reference to HTML5
- made error terminology more consistent
- clarified that only 1 list or leaf-list instance can be returned in an XML response message-body
- clarified that more than 1 instance must not be created by a POST method
- clarified that PUT cannot be used to change a leaf-list value or any list key values
- clarified that PATCH cannot be used to change a leaf-list value or any list key values

- clarified that DELETE should not be used to delete more than one instance of a leaf-list or list
- update JSON RFC reference
- specified that leaf-list instances are data resources
- specified how a leaf-list instance identifier is constructed
- fixed get-schema example
- clarified that if no Accept header the server SHOULD return the type specified in RESTCONF, but MAY return any media-type, according to HTTP rules
- clarified that server SHOULD maintain timestamp and etag for data resources
- clarified default for content query parameter
- moved terminology section earlier in doc to avoid forward usage
- clarified intro text wrt/ interactions with NETCONF and access to specific datastores
- clarified server implementation requirements for YANG defaults
- clarified that Errors is not a resource, just a media type
- clarified that HTTP without TLS MUST NOT be used
- add RESTCONF Extensibility section to make it clear how RESTCONF will be extended in the future
- add text warning that NACM does not work with HTTP caching
- remove sec. 5.2 Message Headers
- remove 202 Accepted from list of used status-lines -- not allowed
- made implementation of OPTIONS MUST instead of SHOULD
- clarified that successful PUT for altering data returns 204
- fixed "point" parameter example
- added example of alternate value for root resource discovery

- added YANG action examples
- fixed some JSON examples
- changed default value for content query parameter to "all"
- changed empty container JSON encoding from "[null]" to "{}"
- added mandatory /restconf/yang-library-version leaf to advertise revision-date of the YANG library implemented by the server
- clarified URI encoding rules for leaf-list
- clarified sec. 2.2 wrt/ certificates and TLS
- added update procedure for entity tag and timestamp

A.4. v08 - v09

- fix introduction text regarding implementation requirements for the ietf-yang-library
- clarified HTTP authentication requirements
- fix host-meta example
- changed list key encoding to clarify that quoted strings are not allowed. Percent-encoded values are used if quotes would be required. A missing key is treated as a zero-length string
- Fixed example of percent-encoded string to match YANG model
- Changed streams examples to align with naming already used

A.5. v07 - v08

- add support for YANG 1.1 action statement
- changed mandatory encoding from XML to XML or JSON
- fix syntax in fields parameter definition
- add meta-data encoding examples for XML and JSON
- remove RFC 2396 references and update with 3986

- change encoding of a key so quoted string are not used, since they are already percent-encoded. A zero-length string is not encoded (/list=foo,,baz)

- Add example of percent-encoded key value

A.6. v06 - v07

- fixed all issues identified in email from Jernej Tuljak in netconf email 2015-06-22

- fixed error example bug where error-urlpath was still used. Changed to error-path.

- added mention of YANG Patch and informative reference

- added support for YANG 1.1, specifically support for anydata and actions

- removed the special field value "*", since it is no longer needed

A.7. v05 - v06

- fixed RESTCONF issue #23 (ietf-restconf-monitoring bug)

A.8. v04 - v05

- changed term 'notification event' to 'event notification'

- removed intro text about framework and meta-model

- removed early mention of API resources

- removed term unified datastore and cleaned up text about NETCONF datastores

- removed text about not immediate persistence of edits

- removed RESTCONF-specific data-resource-identifier typedef and its usage

- clarified encoding of key leafs

- changed several examples from JSON to XML encoding

- made 'insert' and 'point' query parameters mandatory to implement

- removed ":insert" capability URI

- renamed stream/encoding to stream/access
- renamed stream/encoding/type to stream/access/encoding
- renamed stream/encoding/events to stream/access/location
- changed XPath from informative to normative reference
- changed rest-dissertation from normative to informative reference
- changed example-jukebox playlist 'id' from a data-resource-identifier to a leafref pointing at the song name

A.9. v03 - v04

- renamed 'select' to 'fields' (#1)
- moved collection resource and page capability to draft-ietf-netconf-restconf-collection-00 (#3)
- added mandatory "defaults" protocol capability URI (#4)
- added optional "with-defaults" query parameter URI (#4)
- clarified authentication procedure (#9)
- moved ietf-yang-library module to draft-ietf-netconf-yang-library-00 (#13)
- clarified that JSON encoding of module name in a URI MUST follow the netmod-yang-json encoding rules (#14)
- added restconf-media-type extension (#15)
- remove "content" query parameter URI and made this parameter mandatory (#16)
- clarified datastore usage
- changed lock-denied error example
- added with-defaults query parameter example
- added term "RESTCONF Capability"
- changed NETCONF Capability URI registry usage to new RESTCONF Capability URI Registry usage

A.10. v02 - v03

- added collection resource
- added "page" query parameter capability
- added "limit" and "offset" query parameters, which are available if the "page" capability is supported
- added "stream list" term
- fixed bugs in some examples
- added "encoding" list within the "stream" list to allow different <events> URLs for XML and JSON encoding.
- made XML MUST implement and JSON MAY implement for servers
- re-add JSON notification examples (previously removed)
- updated JSON references

A.11. v01 - v02

- moved query parameter definitions from the YANG module back to the plain text sections
- made all query parameters optional to implement
- defined query parameter capability URI
- moved 'streams' to new YANG module (ietf-restconf-monitoring)
- added 'capabilities' container to new YANG module (ietf-restconf-monitoring)
- moved 'modules' container to new YANG module (ietf-yang-library)
- added new leaf 'module-set-id' (ietf-yang-library)
- added new leaf 'conformance' (ietf-yang-library)
- changed 'schema' leaf to type inet:uri that returns the location of the YANG schema (instead of returning the schema directly)
- changed 'events' leaf to type inet:uri that returns the location of the event stream resource (instead of returning events directly)

- changed examples for yang.api resource since the monitoring information is no longer in this resource

- closed issue #1 'select parameter' since no objections to the proposed syntax

- closed "encoding of list keys" issue since no objection to new encoding of list keys in a target resource URI.

- moved open issues list to the issue tracker on github

A.12. v00 - v01

- fixed content=nonconfig example (non-config was incorrect)

- closed open issue 'message-id'. There is no need for a message-id field, and RFC 2392 does not apply.

- closed open issue 'server support verification'. The headers used by RESTCONF are widely supported.

- removed encoding rules from section on RESTCONF Meta-Data. This is now defined in "I-D.lhotka-netmod-yang-json".

- added media type application/yang.errors to map to errors YANG grouping. Updated error examples to use new media type.

- closed open issue 'additional datastores'. Support may be added in the future to identify new datastores.

- closed open issue 'PATCH media type discovery'. The section on PATCH has an added sentence on the Accept-Patch header.

- closed open issue 'YANG to resource mapping'. Current mapping of all data nodes to resources will be used in order to allow mandatory DELETE support. The PATCH operation is optional, as well as the YANG Patch media type.

- closed open issue '_self links for HATEOAS support'. It was decided that they are redundant because they can be derived from the YANG module for the specific data.

- added explanatory text for the 'select' parameter.

- added RESTCONF Path Resolution section for discovering the root of the RESTCONF API using the /.well-known/host-meta.

- added an "error" media type to for structured error messages

- added Secure Transport section requiring TLS
- added Security Considerations section
- removed all references to "REST-like"

A.13. bierman:restconf-04 to ietf:restconf-00

- updated open issues section

Appendix B. Open Issues

-- RFC Ed.: remove this section before publication.

The RESTCONF issues are tracked on github.com:

https://github.com/netconf-wg/restconf/issues

Appendix C. Example YANG Module

The example YANG module used in this document represents a simple media jukebox interface.

YANG Tree Diagram for "example-jukebox" Module

```
+--rw jukebox!
   +--rw library
   |  +--rw artist* [name]
   |  |  +--rw name     string
   |  |  +--rw album* [name]
   |  |     +--rw name     string
   |  |     +--rw genre?   identityref
   |  |     +--rw year?    uint16
   |  |     +--rw admin
   |  |     |  +--rw label?              string
   |  |     |  +--rw catalogue-number?   string
   |  |     +--rw song* [name]
   |  |        +--rw name        string
   |  |        +--rw location    string
   |  |        +--rw format?     string
   |  |        +--rw length?     uint32
   |  +--ro artist-count?   uint32
   |  +--ro album-count?    uint32
   |  +--ro song-count?     uint32
   +--rw playlist* [name]
   |  +--rw name           string
   |  +--rw description?   string
   |  +--rw song* [index]
```

```
      |     +--rw index    uint32
      |     +--rw id       leafref
      +--rw player
         +--rw gap?   decimal64

   rpcs:

   +---x play
      +--ro input
         +--ro playlist       string
         +--ro song-number    uint32
```

C.1. example-jukebox YANG Module

```
   module example-jukebox {

      namespace "http://example.com/ns/example-jukebox";
      prefix "jbox";

      organization "Example, Inc.";
      contact "support at example.com";
      description "Example Jukebox Data Model Module";
      revision "2015-04-04" {
        description "Initial version.";
        reference "example.com document 1-4673";
      }

      identity genre {
        description "Base for all genre types";
      }

      // abbreviated list of genre classifications
      identity alternative {
        base genre;
        description "Alternative music";
      }
      identity blues {
        base genre;
        description "Blues music";
      }
      identity country {
        base genre;
        description "Country music";
      }
      identity jazz {
        base genre;
        description "Jazz music";
      }
```

```
      identity pop {
        base genre;
        description "Pop music";
      }
      identity rock {
        base genre;
        description "Rock music";
      }

      container jukebox {
        presence
          "An empty container indicates that the jukebox
           service is available";

        description
          "Represents a jukebox resource, with a library, playlists,
           and a play operation.";

        container library {

          description "Represents the jukebox library resource.";

          list artist {
            key name;

            description
              "Represents one artist resource within the
               jukebox library resource.";

            leaf name {
              type string {
                length "1 .. max";
              }
              description "The name of the artist.";
            }

            list album {
              key name;

              description
                "Represents one album resource within one
                 artist resource, within the jukebox library.";

              leaf name {
                type string {
                  length "1 .. max";
                }
                description "The name of the album.";
```

```
            }

            leaf genre {
              type identityref { base genre; }
              description
                "The genre identifying the type of music on
                 the album.";
            }

            leaf year {
              type uint16 {
                range "1900 .. max";
              }
              description "The year the album was released";
            }

            container admin {
              description
                "Administrative information for the album.";

              leaf label {
                type string;
                description "The label that released the album.";
              }
              leaf catalogue-number {
                type string;
                description "The album's catalogue number.";
              }
            }

            list song {
              key name;

              description
                "Represents one song resource within one
                 album resource, within the jukebox library.";

              leaf name {
                type string {
                   length "1 .. max";
                }
                description "The name of the song";
              }
              leaf location {
                type string;
                mandatory true;
                description
                 "The file location string of the
```

```
                media file for the song";
            }
            leaf format {
              type string;
              description
                "An identifier string for the media type
                 for the file associated with the
                 'location' leaf for this entry.";
            }
            leaf length {
              type uint32;
              units "seconds";
              description
                "The duration of this song in seconds.";
            }
          }   // end list 'song'
        }   // end list 'album'
      }  // end list 'artist'

      leaf artist-count {
         type uint32;
         units "songs";
         config false;
         description "Number of artists in the library";
      }
      leaf album-count {
         type uint32;
         units "albums";
         config false;
         description "Number of albums in the library";
      }
      leaf song-count {
         type uint32;
         units "songs";
         config false;
         description "Number of songs in the library";
      }
    }  // end library

    list playlist {
      key name;

      description
        "Example configuration data resource";

      leaf name {
        type string;
        description
```

```
            "The name of the playlist.";
        }
        leaf description {
          type string;
          description
            "A comment describing the playlist.";
        }
        list song {
          key index;
          ordered-by user;

          description
            "Example nested configuration data resource";

          leaf index {    // not really needed
            type uint32;
            description
              "An arbitrary integer index for this playlist song.";
          }
          leaf id {
            type leafref {
              path "/jbox:jukebox/jbox:library/jbox:artist/" +
                   "jbox:album/jbox:song/jbox:name";
            }
            mandatory true;
            description
              "Song identifier. Must identify an instance of
               /jukebox/library/artist/album/song/name.";
          }
        }
      }

      container player {
        description
          "Represents the jukebox player resource.";

        leaf gap {
          type decimal64 {
            fraction-digits 1;
            range "0.0 .. 2.0";
          }
          units "tenths of seconds";
          description "Time gap between each song";
        }
      }
    }

    rpc play {
```

```
        description "Control function for the jukebox player";
        input {
          leaf playlist {
            type string;
            mandatory true;
            description "playlist name";
          }
          leaf song-number {
            type uint32;
            mandatory true;
            description "Song number in playlist to play";
          }
        }
      }
    }
```

Appendix D. RESTCONF Message Examples

The examples within this document use the normative YANG module defined in Section 8 and the non-normative example YANG module defined in Appendix C.1.

This section shows some typical RESTCONF message exchanges.

D.1. Resource Retrieval Examples

D.1.1. Retrieve the Top-level API Resource

The client may start by retrieving the top-level API resource, using the entry point URI "{+restconf}".

```
GET /restconf   HTTP/1.1
Host: example.com
Accept: application/yang.api+json
```

The server might respond as follows:

```
   HTTP/1.1 200 OK
   Date: Mon, 23 Apr 2012 17:01:00 GMT
   Server: example-server
   Content-Type: application/yang.api+json

   {
     "ietf-restconf:restconf": {
       "data" : {},
       "operations" : {},
       "yang-library-version" : "2016-04-09"
```

```
      }
    }
```

To request that the response content to be encoded in XML, the "Accept" header can be used, as in this example request:

```
GET /restconf HTTP/1.1
Host: example.com
Accept: application/yang.api+xml
```

The server will return the same response either way, which might be as follows :

```
HTTP/1.1 200 OK
Date: Mon, 23 Apr 2012 17:01:00 GMT
Server: example-server
Cache-Control: no-cache
Pragma: no-cache
Content-Type: application/yang.api+xml

<restconf xmlns="urn:ietf:params:xml:ns:yang:ietf-restconf">
  <data/>
  <operations/>
  <yang-library-version>2016-04-09</yang-library-version>
</restconf>
```

D.1.2. Retrieve The Server Module Information

In this example the client is retrieving the modules information from the server in JSON format:

```
GET /restconf/data/ietf-yang-library:modules HTTP/1.1
Host: example.com
Accept: application/yang.data+json
```

The server might respond as follows (some strings wrapped for display purposes):

```
   HTTP/1.1 200 OK
   Date: Mon, 23 Apr 2012 17:01:00 GMT
   Server: example-server
   Cache-Control: no-cache
   Pragma: no-cache
   Last-Modified: Sun, 22 Apr 2012 01:00:14 GMT
   Content-Type: application/yang.data+json

   {
     "ietf-yang-library:modules": {
```

```
          "module": [
            {
              "name" : "foo",
              "revision" : "2012-01-02",
              "schema" : "https://example.com/modules/foo/2012-01-02",
              "namespace" : "http://example.com/ns/foo",
              "feature" : [ "feature1", "feature2" ],
              "conformance-type" : "implement"
            },
            {
              "name" : "ietf-yang-library",
              "revision" : "2016-04-09",
              "schema" : "https://example.com/modules/ietf-yang-
                library/2016-04-09",
              "namespace" :
                "urn:ietf:params:xml:ns:yang:ietf-yang-library",
              "conformance-type" : "implement"
            },
            {
              "name" : "foo-types",
              "revision" : "2012-01-05",
              "schema" :
                "https://example.com/modules/foo-types/2012-01-05",
              "namespace" : "http://example.com/ns/foo-types",
              "conformance-type" : "import"
            },
            {
              "name" : "bar",
              "revision" : "2012-11-05",
              "schema" : "https://example.com/modules/bar/2012-11-05",
              "namespace" : "http://example.com/ns/bar",
              "feature" : [ "bar-ext" ],
              "conformance-type" : "implement",
              "submodule" : [
                {
                  "name" : "bar-submod1",
                  "revision" : "2012-11-05",
                  "schema" :
                   "https://example.com/modules/bar-submod1/2012-11-05"
                },
                {
                  "name" : "bar-submod2",
                  "revision" : "2012-11-05",
                  "schema" :
                   "https://example.com/modules/bar-submod2/2012-11-05"
                }
              ]
            }
```

```
          ]
        }
      }
```

D.1.3. Retrieve The Server Capability Information

In this example the client is retrieving the capability information from the server in XML format, and the server supports all the RESTCONF query parameters, plus one vendor parameter:

```
GET /restconf/data/ietf-restconf-monitoring:restconf-state/
    capabilities  HTTP/1.1
Host: example.com
Accept: application/yang.data+xml
```

The server might respond as follows. The extra whitespace in 'capability' elements for display purposes only.

```
HTTP/1.1 200 OK
Date: Mon, 23 Apr 2012 17:02:00 GMT
Server: example-server
Cache-Control: no-cache
Pragma: no-cache
Last-Modified: Sun, 22 Apr 2012 01:00:14 GMT
Content-Type: application/yang.data+xml

<capabilities xmlns="">
 <capability>
  urn:ietf:params:restconf:capability:depth:1.0
 </capability>
 <capability>
  urn:ietf:params:restconf:capability:fields:1.0
 </capability>
 <capability>
  urn:ietf:params:restconf:capability:filter:1.0
 </capability>
 <capability>
  urn:ietf:params:restconf:capability:start-time:1.0
 </capability>
 <capability>
  urn:ietf:params:restconf:capability:stop-time:1.0
 </capability>
 <capability>
  http://example.com/capabilities/myparam
 </capability>
</capabilities>
```

D.2. Edit Resource Examples

D.2.1. Create New Data Resources

To create a new "artist" resource within the "library" resource, the client might send the following request.

```
   POST /restconf/data/example-jukebox:jukebox/library HTTP/1.1
   Host: example.com
   Content-Type: application/yang.data+json

   {
     "example-jukebox:artist" : {
       "name" : "Foo Fighters"
     }
   }
```

If the resource is created, the server might respond as follows. Note that the "Location" header line is wrapped for display purposes only:

```
HTTP/1.1 201 Created
Date: Mon, 23 Apr 2012 17:02:00 GMT
Server: example-server
Location: https://example.com/restconf/data/
    example-jukebox:jukebox/library/artist=Foo%20Fighters
Last-Modified: Mon, 23 Apr 2012 17:02:00 GMT
ETag: b3830f23a4c
```

To create a new "album" resource for this artist within the "jukebox" resource, the client might send the following request. Note that the request URI header line is wrapped for display purposes only:

```
POST /restconf/data/example-jukebox:jukebox/
    library/artist=Foo%20Fighters  HTTP/1.1
Host: example.com
Content-Type: application/yang.data+xml

<album xmlns="http://example.com/ns/example-jukebox">
  <name>Wasting Light</name>
  <year>2011</year>
</album>
```

If the resource is created, the server might respond as follows. Note that the "Location" header line is wrapped for display purposes only:

```
HTTP/1.1 201 Created
Date: Mon, 23 Apr 2012 17:03:00 GMT
Server: example-server
Location: https://example.com/restconf/data/
    example-jukebox:jukebox/library/artist=Foo%20Fighters/
    album=Wasting%20Light
Last-Modified: Mon, 23 Apr 2012 17:03:00 GMT
ETag: b8389233a4c
```

D.2.2. Detect Resource Entity Tag Change

In this example, the server just supports the mandatory datastore last-changed timestamp. The client has previously retrieved the "Last-Modified" header and has some value cached to provide in the following request to patch an "album" list entry with key value "Wasting Light". Only the "genre" field is being updated.

```
PATCH /restconf/data/example-jukebox:jukebox/
    library/artist=Foo%20Fighters/album=Wasting%20Light/genre
    HTTP/1.1
Host: example.com
If-Unmodified-Since: Mon, 23 Apr 2012 17:01:00 GMT
Content-Type: application/yang.data+json

{ "example-jukebox:genre" : "example-jukebox:alternative" }
```

In this example the datastore resource has changed since the time specified in the "If-Unmodified-Since" header. The server might respond:

```
HTTP/1.1 412 Precondition Failed
Date: Mon, 23 Apr 2012 19:01:00 GMT
Server: example-server
Last-Modified: Mon, 23 Apr 2012 17:45:00 GMT
ETag: b34aed893a4c
```

D.2.3. Edit a Datastore Resource

In this example, the client modifies two different data nodes by sending a PATCH to the datastore resource:

```
PATCH /restconf/data HTTP/1.1
Host: example.com
Content-Type: application/yang.datastore+xml

<data xmlns="urn:ietf:params:xml:ns:yang:ietf-restconf">
  <jukebox xmlns="http://example.com/ns/example-jukebox">
    <library>
```

```
        <artist>
          <name>Foo Fighters</name>
          <album>
            <name>Wasting Light</name>
            <year>2011</year>
          </album>
        </artist>
        <artist>
          <name>Nick Cave</name>
          <album>
            <name>Tender Prey</name>
            <year>1988</year>
          </album>
        </artist>
      </library>
    </jukebox>
  </data>
```

D.3. Query Parameter Examples

D.3.1. "content" Parameter

The "content" parameter is used to select the type of data child resources (configuration and/or not configuration) that are returned by the server for a GET method request.

In this example, a simple YANG list that has configuration and non-configuration child resources.

```
container events
  list event {
    key name;
    leaf name { type string; }
    leaf description { type string; }
    leaf event-count {
      type uint32;
      config false;
    }
  }
}
```

Example 1: content=all

To retrieve all the child resources, the "content" parameter is set to "all". The client might send:

```
GET /restconf/data/example-events:events?content=all
    HTTP/1.1
```

```
   Host: example.com
   Accept: application/yang.data+json

   The server might respond:

      HTTP/1.1 200 OK
      Date: Mon, 23 Apr 2012 17:11:30 GMT
      Server: example-server
      Cache-Control: no-cache
      Pragma: no-cache
      Content-Type: application/yang.data+json

      {
        "example-events:events" : {
          "event" : [
            {
              "name" : "interface-up",
              "description" : "Interface up notification count",
              "event-count" : 42
            },
            {
              "name" : "interface-down",
              "description" : "Interface down notification count",
              "event-count" : 4
            }
          ]
        }
      }
```

Example 2: content=config

To retrieve only the configuration child resources, the "content" parameter is set to "config" or omitted since this is the default value. Note that the "ETag" and "Last-Modified" headers are only returned if the content parameter value is "config".

```
   GET /restconf/data/example-events:events?content=config
       HTTP/1.1
   Host: example.com
   Accept: application/yang.data+json

   The server might respond:

      HTTP/1.1 200 OK
      Date: Mon, 23 Apr 2012 17:11:30 GMT
      Server: example-server
      Last-Modified: Mon, 23 Apr 2012 13:01:20 GMT
      ETag: eeeada438af
```

```
      Cache-Control: no-cache
      Pragma: no-cache
      Content-Type: application/yang.data+json

      {
        "example-events:events" : {
          "event" : [
            {
              "name" : "interface-up",
              "description" : "Interface up notification count"
            },
            {
              "name" : "interface-down",
              "description" : "Interface down notification count"
            }
          ]
        }
      }
```

Example 3: content=nonconfig

To retrieve only the non-configuration child resources, the "content" parameter is set to "nonconfig". Note that configuration ancestors (if any) and list key leafs (if any) are also returned. The client might send:

```
GET /restconf/data/example-events:events?content=nonconfig
    HTTP/1.1
Host: example.com
Accept: application/yang.data+json
```

The server might respond:

```
   HTTP/1.1 200 OK
   Date: Mon, 23 Apr 2012 17:11:30 GMT
   Server: example-server
   Cache-Control: no-cache
   Pragma: no-cache
   Content-Type: application/yang.data+json

   {
     "example-events:events" : {
       "event" : [
         {
           "name" : "interface-up",
           "event-count" : 42
         },
         {
```

```
            "name" : "interface-down",
            "event-count" : 4
          }
        ]
      }
    }
```

D.3.2. "depth" Parameter

The "depth" parameter is used to limit the number of levels of child resources that are returned by the server for a GET method request.

The depth parameter starts counting levels at the level of the target resource that is specified, so that a depth level of "1" includes just the target resource level itself. A depth level of "2" includes the target resource level and its child nodes.

This example shows how different values of the "depth" parameter would affect the reply content for retrieval of the top-level "jukebox" data resource.

Example 1: depth=unbounded

To retrieve all the child resources, the "depth" parameter is not present or set to the default value "unbounded". Note that some strings are wrapped for display purposes only.

```
GET /restconf/data/example-jukebox:jukebox?depth=unbounded
    HTTP/1.1
Host: example.com
Accept: application/yang.data+json
```

The server might respond:

```
   HTTP/1.1 200 OK
   Date: Mon, 23 Apr 2012 17:11:30 GMT
   Server: example-server
   Cache-Control: no-cache
   Pragma: no-cache
   Content-Type: application/yang.data+json

   {
     "example-jukebox:jukebox" : {
       "library" : {
         "artist" : [
           {
             "name" : "Foo Fighters",
             "album" : [
```

```
                {
                  "name" : "Wasting Light",
                  "genre" : "example-jukebox:alternative",
                  "year" : 2011,
                  "song" : [
                    {
                      "name" : "Wasting Light",
                      "location" :
                        "/media/foo/a7/wasting-light.mp3",
                      "format" : "MP3",
                      "length" " 286
                    },
                    {
                      "name" : "Rope",
                      "location" : "/media/foo/a7/rope.mp3",
                      "format" : "MP3",
                      "length" " 259
                    }
                  ]
                }
              ]
            }
          ]
        },
        "playlist" : [
          {
            "name" : "Foo-One",
            "description" : "example playlist 1",
            "song" : [
              {
                "index" : 1,
                "id" : "https://example.com/restconf/data/
                      example-jukebox:jukebox/library/artist=
                      Foo%20Fighters/album=Wasting%20Light/
                      song=Rope"
              },
              {
                "index" : 2,
                "id" : "https://example.com/restconf/data/
                      example-jukebox:jukebox/library/artist=
                      Foo%20Fighters/album=Wasting%20Light/song=
                      Bridge%20Burning"
              }
            ]
          }
        ],
        "player" : {
          "gap" : 0.5
```

```
        }
      }
    }
```

Example 2: depth=1

To determine if 1 or more resource instances exist for a given target resource, the value "1" is used.

```
GET /restconf/data/example-jukebox:jukebox?depth=1 HTTP/1.1
Host: example.com
Accept: application/yang.data+json
```

The server might respond:

```
   HTTP/1.1 200 OK
   Date: Mon, 23 Apr 2012 17:11:30 GMT
   Server: example-server
   Cache-Control: no-cache
   Pragma: no-cache
   Content-Type: application/yang.data+json

   {
     "example-jukebox:jukebox" : {}
   }
```

Example 3: depth=3

To limit the depth level to the target resource plus 2 child resource layers the value "3" is used.

```
GET /restconf/data/example-jukebox:jukebox?depth=3 HTTP/1.1
Host: example.com
Accept: application/yang.data+json
```

The server might respond:

```
   HTTP/1.1 200 OK
   Date: Mon, 23 Apr 2012 17:11:30 GMT
   Server: example-server
   Cache-Control: no-cache
   Pragma: no-cache
   Content-Type: application/yang.data+json

   {
     "example-jukebox:jukebox" : {
       "library" : {
         "artist" : {}
```

```
          },
          "playlist" : [
            {
              "name" : "Foo-One",
              "description" : "example playlist 1",
              "song" : {}
            }
          ],
          "player" : {
            "gap" : 0.5
          }
        }
      }
```

D.3.3. "fields" Parameter

In this example the client is retrieving the API resource, but retrieving only the "name" and "revision" nodes from each module, in JSON format:

```
GET /restconf/data?fields=ietf-yang-library:modules/
    module(name;revision) HTTP/1.1
Host: example.com
Accept: application/yang.data+json
```

The server might respond as follows.

```
   HTTP/1.1 200 OK
   Date: Mon, 23 Apr 2012 17:01:00 GMT
   Server: example-server
   Content-Type: application/yang.data+json

   {
     "ietf-yang-library:modules": {
       "module": [
         {
           "name" : "example-jukebox",
           "revision" : "2015-06-04"
         },
         {
           "name" : "ietf-inet-types",
           "revision" : "2013-07-15"
         },
         {
           "name" : "ietf-restconf-monitoring",
           "revision" : "2015-06-19"
         },
         {
```

```
            "name" : "ietf-yang-library",
            "revision" : "2016-04-09"
          },
          {
            "name" : "ietf-yang-types",
            "revision" : "2013-07-15"
          }

        ]
      }
    }
```

D.3.4. "insert" Parameter

In this example, a new first song entry in the "Foo-One" playlist is being created.

Request from client:

```
POST /restconf/data/example-jukebox:jukebox/
    playlist=Foo-One?insert=first HTTP/1.1
Host: example.com
Content-Type: application/yang.data+json

{
  "example-jukebox:song" : {
     "index" : 1,
     "id" : "/example-jukebox:jukebox/library/
         artist=Foo%20Fighters/album=Wasting%20Light/song=Rope"
   }
}
```

Response from server:

```
HTTP/1.1 201 Created
Date: Mon, 23 Apr 2012 13:01:20 GMT
Server: example-server
Last-Modified: Mon, 23 Apr 2012 13:01:20 GMT
Location: https://example.com/restconf/data/
    example-jukebox:jukebox/playlist=Foo-One/song=1
ETag: eeeada438af
```

D.3.5. "point" Parameter

In this example, the client is inserting a new "song" resource within an "album" resource after another song. The request URI is split for display purposes only.

Request from client:

```
POST /restconf/data/example-jukebox:jukebox/
    library/artist=Foo%20Fighters/album=Wasting%20Light?
    insert=after&point=%2Fexample-jukebox%3Ajukebox%2F
    library%2Fartist%3DFoo%20Fighters%2Falbum%3D
    Wasting%20Light%2Fsong%3DBridge%20Burning   HTTP/1.1
Host: example.com
Content-Type: application/yang.data+json

{
  "example-jukebox:song" : {
    "name" : "Rope",
    "location" : "/media/foo/a7/rope.mp3",
    "format" : "MP3",
    "length" : 259
  }
}
```

Response from server:

```
HTTP/1.1 204 No Content
Date: Mon, 23 Apr 2012 13:01:20 GMT
Server: example-server
Last-Modified: Mon, 23 Apr 2012 13:01:20 GMT
ETag: abcada438af
```

D.3.6. "filter" Parameter

The following URIs show some examples of notification filter specifications (lines wrapped for display purposes only):

```
// filter = /event/event-class='fault'
GET /streams/NETCONF?filter=%2Fevent%2Fevent-class%3D'fault'

// filter = /event/severity<=4
GET /streams/NETCONF?filter=%2Fevent%2Fseverity%3C%3D4

// filter = /linkUp|/linkDown
GET /streams/SNMP?filter=%2FlinkUp%7C%2FlinkDown

// filter = /*/reporting-entity/card!='Ethernet0'
GET /streams/NETCONF?
   filter=%2F*%2Freporting-entity%2Fcard%21%3D'Ethernet0'

// filter = /*/email-addr[contains(.,'company.com')]
GET /streams/critical-syslog?
   filter=%2F*%2Femail-addr[contains(.%2C'company.com')]
```

```
      // Note: the module name is used as prefix.
      // filter = (/example-mod:event1/name='joe' and
      //           /example-mod:event1/status='online')
      GET /streams/NETCONF?
        filter=(%2Fexample-mod%3Aevent1%2Fname%3D'joe'%20and
                %20%2Fexample-mod%3Aevent1%2Fstatus%3D'online')

      // To get notifications from just two modules (e.g., m1 + m2)
      // filter=(/m1:* or /m2:*)
      GET /streams/NETCONF?filter=(%2Fm1%3A*%20or%20%2Fm2%3A*)
```

D.3.7. "start-time" Parameter

```
   // start-time = 2014-10-25T10:02:00Z
   GET /streams/NETCONF?start-time=2014-10-25T10%3A02%3A00Z
```

D.3.8. "stop-time" Parameter

```
   // stop-time = 2014-10-25T12:31:00Z
   GET /mystreams/NETCONF?stop-time=2014-10-25T12%3A31%3A00Z
```

D.3.9. "with-defaults" Parameter

The following YANG module is assumed for this example.

```
     module example-interface {
       prefix "exif";
       namespace "urn:example.com:params:xml:ns:yang:example-interface";

       container interfaces {
         list interface {
           key name;
           leaf name { type string; }
           leaf mtu { type uint32; }
           leaf status {
             config false;
             type enumeration {
               enum up;
               enum down;
               enum testing;
             }
           }
         }
       }
     }
```

Assume the same data model as defined in Appendix A.1 of [RFC6243].
Assume the same data set as defined in Appendix A.2 of [RFC6243]. If

the server defaults-uri basic-mode is "trim", the the following request for interface "eth1" might be as follows:

Without query parameter:

```
GET /restconf/data/example:interfaces/interface=eth1 HTTP/1.1
Host: example.com
Accept: application/yang.data+json
```

The server might respond as follows.

```
   HTTP/1.1 200 OK
   Date: Mon, 23 Apr 2012 17:01:00 GMT
   Server: example-server
   Content-Type: application/yang.data+json

   {
     "example:interface": [
       {
         "name" : "eth1",
         "status" : "up"
       }
     ]
   }
```

Note that the "mtu" leaf is missing because it is set to the default "1500", and the server defaults handling basic-mode is "trim".

With query parameter:

```
GET /restconf/data/example:interfaces/interface=eth1
    ?with-defaults=report-all HTTP/1.1
Host: example.com
Accept: application/yang.data+json
```

The server might respond as follows.

```
   HTTP/1.1 200 OK
   Date: Mon, 23 Apr 2012 17:01:00 GMT
   Server: example-server
   Content-Type: application/yang.data+json

   {
     "example:interface": [
       {
         "name" : "eth1",
         "mtu" : 1500,
         "status" : "up"
```

```
          }
        ]
      }
```

Note that the server returns the "mtu" leaf because the "report-all" mode was requested with the "with-defaults" query parameter.

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