

Network Working Group
Internet-Draft
Intended status: Standards Track
Expires: April 22, 2014

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October 19, 2013

RESTCONF Protocol
draft-bierman-netconf-restconf-02

Abstract

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

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Table of Contents

1.	Introduction	5
1.1.	Simple Subset of NETCONF Functionality	5
1.2.	Data Model Driven API	6
1.3.	Terminology	7
1.3.1.	NETCONF	7
1.3.2.	HTTP	8
1.3.3.	YANG	8
1.3.4.	Terms	9
1.3.5.	Tree Diagrams	10
1.4.	Overview	11
1.4.1.	Resource URI Map	11
1.4.2.	RESTCONF Message Examples	12
2.	Framework	20
2.1.	Message Model	20
2.2.	Notification Model	20
2.2.1.	Server Support	20
2.2.2.	Event Stream Discovery	20
2.2.3.	Subscribing to Receive Notifications	21
2.2.4.	Receiving Event Notifications	24
2.3.	Resource Model	25
2.3.1.	RESTCONF Resource Types	26
2.3.2.	Resource Discovery	26
2.4.	Datastore Model	27
2.4.1.	Content Model	27
2.4.2.	Editing Model	28
2.4.3.	Locking Model	29
2.4.4.	Persistence Model	29
2.4.5.	Defaults Model	29
2.5.	Transaction Model	30
2.6.	Extensibility Model	30
2.7.	Versioning Model	30
2.8.	Retrieval Filtering Model	31
2.9.	Access Control Model	31
3.	Operations	32
3.1.	OPTIONS	32
3.2.	HEAD	34
3.3.	GET	34
3.4.	POST	36
3.4.1.	Create Resource Mode	36
3.4.2.	Invoke Operation Mode	37
3.5.	PUT	37

3.6.	PATCH	38
3.7.	DELETE	38
3.8.	Query Parameters	38
3.8.1.	"depth" Parameter	39
3.8.2.	"format" Parameter	41
3.8.3.	"insert" Parameter	42
3.8.4.	"point" Parameter	43
3.8.5.	"select" Parameter	44
3.9.	Protocol Operations	45
4.	Messages	46
4.1.	Request URI Structure	46
4.2.	Message Headers	47
4.3.	Message Encoding	48
4.4.	RESTCONF Meta-Data	48
4.4.1.	JSON Encoding of RESTCONF Meta-Data	49
4.5.	Return Status	51
4.6.	Message Caching	51
5.	Resources	52
5.1.	API Resource (/restconf)	52
5.1.1.	/restconf/config	53
5.1.2.	/restconf/operational	53
5.1.3.	/restconf/modules	54
5.1.4.	/restconf/operations	56
5.1.5.	/restconf/streams	56
5.2.	Datastore Resource	56
5.3.	Data Resource	57
5.3.1.	Encoding YANG Instance Identifiers in the Request URI	57
5.3.2.	Data Resource Retrieval	60
5.4.	Operation Resource	61
5.4.1.	Encoding Operation Input Parameters	61
5.4.2.	Encoding Operation Output Parameters	62
5.5.	Stream Resource	63
6.	Error Reporting	64
6.1.	Error Response Message	65
7.	YANG Patch	67
7.1.	Why not use JSON Patch?	68
7.2.	YANG Patch Target Data Node	69
7.3.	YANG Patch Edit Operations	69
7.4.	YANG Patch Error Handling	69
7.5.	YANG Patch Response	70
7.6.	YANG Patch Examples	70
7.6.1.	Add Resources: Error	70
7.6.2.	Add Resources: Success	72
7.6.3.	Move list entry example	74
8.	RESTCONF module	76
9.	IANA Considerations	91
9.1.	YANG Module Registry	91

9.2. application/yang Media Type	91
10. Security Considerations	92
11. References	93
11.1. Normative References	93
11.2. Informative References	94
Appendix A. Change Log	95
A.1. 01 to 02	95
A.2. 00 to 01	95
A.3. YANG-API-01 to RESTCONF-00	96
Appendix B. Closed Issues	98
Appendix C. Open Issues	100
C.1. message-id	100
C.2. select parameter	100
C.3. server support verification	100
C.4. error media type	100
C.5. additional datastores	100
C.6. PATCH media type discovery	100
C.7. RESTCONF version	100
C.8. YANG to resource mapping	101
C.9. .well-known usage	101
C.10. _self links for HATEOAS support	102
C.11. netconf-state monitoring support	102
C.12. secure transport	102
Appendix D. Example YANG Module	103
D.1. example-jukebox YANG Module	103
Authors' Addresses	109

1. Introduction

There is a need for standard mechanisms to allow WEB applications to access the configuration data, operational data, data-model specific protocol operations, and notification events within a networking device, in a modular and extensible manner.

This document describes a RESTful protocol called RESTCONF, running over HTTP [[RFC2616](#)], for accessing data defined in YANG [[RFC6020](#)], using datastores defined in NETCONF [[RFC6241](#)].

The NETCONF protocol 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, operational data, custom protocol operations, and notification events. RESTful operations are used to access the hierarchical data within a datastore.

A RESTful API can be created that provides CRUD operations on a NETCONF datastore containing YANG-defined data. This can be done in a simplified manner, compatible with HTTP and RESTful design principles. Since NETCONF protocol operations are not relevant, the user should not need any prior knowledge of NETCONF in order to use the RESTful API.

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-model specific protocol operations defined with the YANG "rpc" statement can be invoked with the POST method. Data-model specific notification events defined with the YANG "notification" statement can be accessed.

1.1. Simple Subset of NETCONF Functionality

The framework and meta-model used for a RESTful API does not need to mirror those used by the NETCONF protocol, but it needs to be compatible with NETCONF. A simplified framework and protocol is needed that utilizes the three NETCONF datastores (candidate, running, startup), but hides the complexity of multiple datastores from the client.

A simplified transaction model is needed that allows basic CRUD operations on a hierarchy of conceptual resources. This represents a limited subset of the transaction capabilities of the NETCONF protocol.

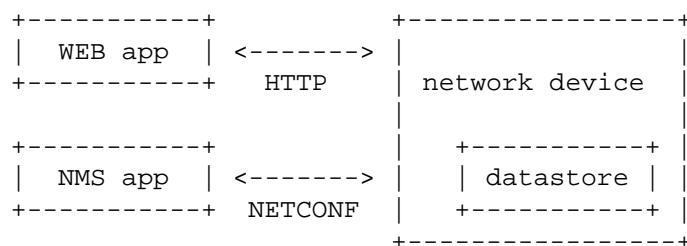
Applications that require more complex transaction capabilities might

consider NETCONF instead of RESTCONF. The following transaction features are not directly provided in RESTCONF:

- o datastore locking (full or partial)
- o candidate datastore
- o startup datastore
- o validate operation
- o confirmed-commit procedure

The RESTful API is not intended to replace NETCONF, but rather provide an additional simplified interface that follows RESTful principles and is compatible with a resource-oriented device abstraction. It is expected that applications that need the full feature set of NETCONF will continue to use NETCONF.

The following figure shows the system components:



1.2. Data Model Driven API

RESTCONF combines the simplicity of a RESTful API over HTTP with the predictability and automation potential of a schema-driven API.

A RESTful client using HATEOAS principles would not use any data modeling language to define the application-specific content of the API. The client would discover each new child resource as it traverses the URIs returned as Location IDs to discover the server capabilities.

This approach has 3 significant weaknesses wrt/ control of complex networking devices:

- o inefficient performance: configuration APIs will be quite complex and may require thousands of protocol messages to discover all the schema information. Typically the data type information has to be passed in the protocol messages, which is also wasteful overhead.

- o no data model richness: without a data model, the schema-level semantics and validation constraints are not available to the application.
- o no tool automation: API automation tools need some sort of content schema to function. Such tools can automate various programming and documentation tasks related to specific data models.

Data model modules such as YANG modules serve as an "API contract" that will be honored by the server. An application designer can code to the data model, knowing in advance important details about the exact protocol operations and datastore content a conforming server implementation will support.

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.

Operational experience with CLI and SNMP indicates that operators learn the 'location' of specific service or device related data and do not expect such information to be arbitrary and discovered each time the client opens a management session to a server.

1.3. 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](#)].

1.3.1. NETCONF

The following terms are defined in [[RFC6241](#)]:

- o candidate configuration datastore
- o client
- o configuration data
- o datastore
- o configuration datastore
- o protocol operation

- o running configuration datastore
- o server
- o startup configuration datastore
- o state data
- o user

1.3.2. HTTP

The following terms are defined in [[RFC2616](#)]:

- o entity tag
- o fragment
- o header line
- o message body
- o method
- o path
- o query
- o request URI
- o response body

1.3.3. YANG

The following terms are defined in [[RFC6020](#)]:

- o container
- o data node
- o key leaf
- o leaf
- o leaf-list
- o list

- o presence container (or P-container)
- o RPC operation (now called protocol operation)
- o non-presence container (or NP-container)
- o ordered-by system
- o ordered-by user

1.3.4. Terms

The following terms are used within this document:

- o API resource: a resource with the media type "application/yang.api+xml" or "application/yang.api+json". API resources can only be edited by the server.
- o data resource: a resource with the media type "application/yang.data+xml" or "application/yang.data+json". Data resources can be edited by clients or the server. Only YANG containers and lists can be data resources. Top-level YANG terminals are treated as fields within the datastore resource.
- o datastore resource: a resource with the media type "application/yang.datastore+xml" or "application/yang.datastore+json". Datastore resources can only be edited by the server.
- o edit operation: a RESTCONF operation on a data resource using the POST, PUT, PATCH, or DELETE method.
- o event stream resource: a resource with the media type "application/yang.stream+xml" or "application/yang.stream+json". This resource represents an SSE event stream. The content consists of text using the media type "text/event-stream". Each event represents one <notification> message generated by the server. It contains a conceptual system or data-model specific event that is delivered within a notification event stream.
- o field: a YANG terminal node within a resource.
- o operation: the conceptual RESTCONF operation for a message, derived from the HTTP method, request URI, headers, and message body.
- o operation resource: a resource with the media type "application/yang.operation+xml" or "application/yang.operation+json".

- o patch: a generic PATCH operation on the target datastore. The media type of the message body content will identify the patch type in use.
- o plain patch: a PATCH operation where the media type is "application/yang.data+xml" or "application/yang.data+json".
- o query parameter: a parameter (and its value if any), encoded within the query component of the request URI.
- o resource: a conceptual object representing a manageable component within a device. Refers to the resource itself of the resource and all its fields.
- o retrieval request: an operation using the GET or HEAD methods.
- o target resource: the resource that is associated with a particular message, identified by the "path" component of the request URI.
- o unified datastore: A conceptual representation of the device running configuration. The server will hide all NETCONF datastore details for edit operations, such as the ":candidate" and ":startup" capabilities.
- o YANG Patch: a PATCH operation where the media type is "application/yang.patch+xml" or "application/yang.patch+json".
- o YANG Patch Status: the status data returned for a YANG Patch operation identified by the media type "application/yang.patch-status+xml" or "application/yang.patch-status+json".
- o YANG terminal node: a YANG node representing a leaf, leaf-list, or anyxml definition.

1.3.5. 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:

- o Brackets "[" and "]" enclose list keys.
- o Abbreviations before data node names: "rw" means configuration (read-write) and "ro" state data (read-only).
- o Symbols after data node names: "?" means an optional node and "*" denotes a "list" and "leaf-list".

- o Parentheses enclose choice and case nodes, and case nodes are also marked with a colon (":").
- o Ellipsis ("...") stands for contents of subtrees that are not shown.

1.4. Overview

This document defines the RESTCONF protocol, a RESTful API for accessing conceptual datastores containing data defined with the YANG language. RESTCONF provides an application framework and meta-model, using HTTP methods.

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 additional data model specific operations, top-level data node resources, and notification event messages supported by the server.

1.4.1. Resource URI Map

The URI hierarchy for the RESTCONF resources consists of an entry point container, 4 top-level resources, and 1 field. Refer to [Section 5](#) for details on each URI.

```
/restconf
  /config
    /<top-level-data-nodes> (configuration data)
  /operational
    /<top-level-data-nodes> (operational data)
  /modules
    /module
      /name
      /revision
      /namespace
      /feature
      /deviation
    /operations
      /<custom protocol operations>
  /streams
    /stream
      /name
      /description
      /replay-support
      /replay-log-creation-time
      /events
  /version (field)
```

1.4.2. 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 D.1](#).

This section shows some typical RESTCONF message exchanges.

1.4.2.1. 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?format=json 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": {
    "config" : [ null ],
    "operational" : [ null ],
    "modules": {
      "module": [
        {
          "name" : "example-jukebox",
          "revision" : "2013-10-19",
          "namespace" : "http://example.com/ns/example-jukebox"
        }
      ]
    },
    "operations" : {
      "play" : [ null ]
    },
    "streams" : {
      "stream" : [
        {
          "name" : "NETCONF",
          "description" : "default NETCONF event stream",
          "replay-support" : true,
          "replay-log-creation-time" : "2007-07-08T00:00:00Z",
          "events" : [ null ]
        }
      ]
    }
  },
  "version": "1.0"
}
```

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
```

An alternate approach is provided using the "format" query parameter, as in this example request:

```
GET /restconf?format=xml HTTP/1.1
Host: example.com
```

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">
  <config/>
  <operational/>
  <modules>
    <module>
      <name>example-jukebox</name>
      <revision>2013-10-19</revision>
      <namespace>
        http://example.com/ns/example-jukebox
      </namespace>
    </module>
  </modules>
  <operations>
    <play xmlns="http://example.com/ns/example-jukebox"/>
  </operations>
  <streams>
    <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>
      <events/>
    </stream>
  </streams>
  <version>1.0</version>
</restconf>
```

Refer to [Section 3.3](#) for details on the GET method.

1.4.2.2. Create New Data Resources

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

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

{ "example-jukebox:jukebox" : [null] }
```

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: http://example.com/restconf/config/
         example-jukebox:jukebox
Last-Modified: Mon, 23 Apr 2012 17:01:00 GMT
ETag: b3a3e673be2
```

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

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

{
  "example-jukebox:album" : {
    "name" : "Wasting Light",
    "genre" : "example-jukebox:alternative",
    "year" : 2012      # note this is the wrong date
  }
}
```

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: http://example.com/restconf/config/
  example-jukebox:jukebox/library/artist/Foo%20Fighters/
  album/Wasting%20Light
Last-Modified: Mon, 23 Apr 2012 17:03:00 GMT
ETag: b8389233a4c
```

Refer to [Section 3.4](#) for details on the POST method.

1.4.2.3. Replace an Existing Data Resource

Note: replacing a resource is a fairly drastic operation. The PATCH method is often more appropriate.

The album sub-resource is replaced here for example purposes only. To replace the "album" resource contents, the client might send as follows. Note that the request URI header line is wrapped for display purposes only:


```
PUT /restconf/config/example-jukebox:jukebox/
    library/artist/Foo%20Fighters/album/Wasting%20Light HTTP/1.1
Host: example.com
If-Match: b3830f23a4c
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
```

Refer to [Section 3.5](#) for details on the PUT method.

1.4.2.4. Patch an Existing Data Resource

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

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

{ "example-jukebox:year" : 2011 }
```

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
```

The XML encoding for the same request might be:

```
PATCH /restconf/config/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
```

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

Refer to [Section 3.6](#) for details on the PATCH method.

1.4.2.5. Delete an Existing Data Resource

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

```
DELETE /restconf/config/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
```

Refer to [Section 3.7](#) for details on the DELETE method.

1.4.2.6. Delete an Optional Field Within a Data Resource

The DELETE method cannot be used to delete an optional field within a resource. This can only be done using the PATCH method with the YANG Patch media type.

Refer to [Section 7](#) for details on the YANG Patch method.

1.4.2.7. Invoke a Data Model Specific Operation

To invoke a data-model specific operation via an operation resource, the POST method is used. A client might send a "backup-datastore" request as follows:

```
POST /restconf/operations/example-ops:backup-datastore HTTP/1.1  
Host: example.com
```

The server might respond:

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

Refer to [Section 3.9](#) for details on using the POST method with operation resources.

2. Framework

The RESTCONF protocol defines a framework that can be used to implement a common API for configuration management. This section describes the components of the RESTCONF framework.

2.1. Message Model

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.

2.2. Notification Model

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

2.2.1. Server Support

A RESTCONF server is not required to support RESTCONF notifications. Clients may determine if a server supports RESTCONF notifications by using the HTTP operation OPTIONS, HEAD, or GET on the "/restconf/streams" resource described below. The server does not support RESTCONF notifications if an HTTP error code is returned (e.g. 404 Not Found).

2.2.2. Event Stream Discovery

A RESTCONF client retrieves the list of supported event streams from a RESTCONF server using the GET operation on the "/restconf/streams" resource.

The "/restconf/streams" container definition in the "ietf-restconf" module defined in Section 8 is used to specify the structure and syntax of the conceptual fields and sub-resources within the "streams" resource.

For example:

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

Available event streams for the requesting session are returned

according the YANG container [[RFC5277](#)]:

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

```
<streams xmlns="urn:ietf:params:xml:ns:yang:ietf-restconf">
  <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>
    <events/>
  </stream>
  <stream>
    <name>SNMP</name>
    <description>SNMP notifications</description>
    <replay-support>false</replay-support>
    <events/>
  </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>
    <events/>
  </stream>
</streams>
```

2.2.3. Subscribing to Receive Notifications

RESTCONF clients can subscribe to receive notifications by sending an HTTP GET to the `/restconf/streams/stream/<stream-name>` resource with the "Accept" type `"text/event-stream"`, which signals the desire to use the Server Sent Events [[wd-eventsource](#)] transport strategy.

For example:

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

2.2.3.1. Query Parameters

Consistent with [RFC5277], RESTCONF notification subscriptions may specify parameters indicating the events it wishes to receive. These parameters are passed in RESTCONF using HTTP query parameters as follows:

2.2.3.1.1. start-time

An optional parameter used to trigger the 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 the /restconf/streams resource, then the server MUST return the HTTP error code 400 Bad Request. If the "start-time" parameter is not present, this is not a replay subscription. It is not valid to specify start times that are later than the current time. If the "start-time" specified is earlier than the log can support, the replay will begin with the earliest available notification. This parameter is of YANG type "date-and-time" from the "ietf-inet-types" module in [RFC6991].

Example: (line wrapped for display purposes only)

```
GET /restconf/streams/stream/syslog-critical/events?
start-time=2012-12-31T23:59:59Z
```

2.2.3.1.2. stop-time

The optional "stop-time" parameter is used with the optional 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. If the "stop-time" parameter is not present, the notifications will continue until the subscription is terminated. Values of "stop-time" in the future are valid. This parameter is of YANG type "date-and-time" from the "ietf-inet-types" module in [RFC6991].

Example: (\'\' added for formatting only)

```
GET /restconf/events?start-time=2013-12-31T23:59:00Z;\
stop-time=2014-01-01T00:01:00Z
```

2.2.3.1.3. filter

The optional "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. The format of this parameter is an XPath expression as defined in [XPath]. The XPath filter expression is evaluated in the following context:

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

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 notification event is delivered to the client.

Examples: (lines wrapped for display purposes only)

```
// filter = /event/eventClass='fault'
GET /restconf/streams/stream/NETCONF/events?
    filter=%2Fevent%2FeventClass%3D'fault'

// filter = /event/severityCode<=4
GET /restconf/streams/stream/NETCONF/events?
    filter=%2Fevent%2FseverityCode%3C%3D4

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

// filter = /*/reportingEntity/card!='Ethernet0'
GET /restconf/streams/stream/NETCONF/events?
    filter=%2F*%2FreportingEntity%2Fcard%21%3D'Ethernet0'

// filter = /*/email-addr[contains(.,'company.com')]
GET /restconf/streams/stream/critical-syslog/events?
    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 /restconf/streams/stream/NETCONF/events?
    filter=(%2Fexample-mod%3Aevent1%2Fname%3D'joe'%20and
            %20%2Fexample-mod%3Aevent1%2Fstatus%3D'online')
```

2.2.4. Receiving Event Notifications

RESTCONF notifications are encoded per NETCONF Event Notifications [RFC5277], though they may be in either XML or JSON format, depending on value of the "format" query parameter passed by the client. The structure of the event data MUST conform to the "notification" element definition in [section 4 of \[RFC5277\]](#).

An example SSE notification encoded using XML:

```
data: <notification
data:   xmlns="urn:ietf:params:xml:ns:yang:ietf-restconf">
data:   <event-time>2013-09-30T00:01:00Z</event-time>
data:   <event xmlns="http://example.com/event/1.0">
data:     <eventClass>fault</eventClass>
data:     <reportingEntity>
data:       <card>Ethernet0</card>
data:     </reportingEntity>
data:     <severity>major</severity>
data:   </event>
data: </notification>
```


An example SSE notification encoded using JSON:

```
data: {
  data: "ietf-restconf:notification": {
    data: "eventTime": "2013-09-30T00:01:00Z",
    data: "example-mod:event": {
      data: "eventClass": "fault",
      data: "reportingEntity": { "card": "Ethernet0" },
      data: "severity": "major"
    }
  }
}
```

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

XML: (‘\’ line wrapping added for formatting only)

```
data: <notification xmlns="urn:ietf:params:xml:ns:yang:ietf-rest\
conf"><event-time>2013-09-30T00:01:00Z</event-time><event xmlns="\
http://example.com/event/1.0"><eventClass>fault</eventClass><repo\
rtingEntity><card>Ethernet0</card></reportingEntity><severity>maj\
or</severity></event></notification>
```

JSON: (‘\’ line wrapping added for formatting only)

```
data: { "ietf-restconf:notification": { "event-time": "2013-09-30\
T00:01:00Z", "example-mod:event": { "eventClass": "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.

2.3. Resource Model

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

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

A resource has its own 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 resources are defined in this document except datastore contents, protocol operations, and notification events. The syntax and semantics for these resource types are defined in YANG modules.

2.3.1. RESTCONF Resource Types

The RESTCONF protocol defines some application specific media types to identify each of the available resource types. The following table summarizes the purpose of each resource.

Resource	Media Type
API	application/yang.api
Datastore	application/yang.datastore
Data	application/yang.data
Operation	application/yang.operation
Patch	application/yang.patch
Patch Status	application/yang.patch-status
Stream	application/yang.stream

RESTCONF Media Types

These resources are described in [Section 5](#).

2.3.2. Resource Discovery

A client SHOULD start by retrieving the top-level API resource, using the entry point URI `"/restconf"`.

The RESTCONF protocol does not include a 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.

The "depth" query parameter can be used to control how many

descendant levels should be included when retrieving sub-resources. This parameter can be used with the GET method to discover sub-resources within a particular resource.

Refer to [Section 3.8.1](#) for more details on the "depth" parameter.

2.4. Datastore Model

A conceptual "unified datastore" is used to simplify resource management for the client. The RESTCONF unified datastore is a combination of the running configuration and any non-configuration data supported by the device. By default only configuration data is returned by a GET method on the datastore contents.

The underlying NETCONF datastores can be used to implement the unified datastore, but the server design is not limited to the exact datastore procedures defined in NETCONF.

The "candidate" and "startup" datastores are not visible in the RESTCONF protocol. Transaction management and configuration persistence are handled by the server and not controlled by the client.

2.4.1. Content Model

The RESTCONF protocol operates on a conceptual datastore defined with the YANG data modeling language. The server lists each YANG module it supports under `/restconf/modules` in the top-level API resource type, using a structure based on the YANG module capability URI format defined in [RFC 6020](#).

The conceptual datastore contents, data-model-specific operations and notification events are identified by this set of YANG module resources. All RESTCONF content identified as either a data resource, operation resource, or event stream resource is defined with the YANG language.

The classification of data as configuration or non-configuration is derived from the YANG "config" statement. Data retrieval with the GET method can be filtered in several ways, including the "config" parameter to retrieve configuration or non-configuration data.

Data ordering behavior is derived from the YANG "ordered-by" statement. The YANG Patch operation is provided to allow list or leaf-list fields to be inserted or moved in the same manner as NETCONF.

2.4.2. Editing Model

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.

Applications which need more control over the editing model might consider using NETCONF instead of RESTCONF.

2.4.2.1. Edit Operation Discovery

The OPTIONS method can be used to identify which HTTP methods are supported by the server for a particular resource. For example, if the server will allow a data resource node to be created then the POST method will be returned in the response.

2.4.2.2. Edit Collision Detection

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

- o timestamp: the last change time is maintained and the "Last-Modified" and "Date" headers are 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.
- o entity tag: a unique opaque string is maintained and the "ETag" 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 these properties for datastore resources, and **MAY** maintain them for individual data resources.

Example:

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 replace a list entry with key value "11":

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

{ "example-jukebox:year" : "2011" }
```

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
```

2.4.4.3. Locking Model

Datastore locking is not provided by RESTCONF. An application that needs to make several changes to the running configuration datastore contents in sequence, without disturbance from other clients might consider using the NETCONF protocol instead of RESTCONF.

2.4.4.4. Persistence Model

Each RESTCONF edit of a datastore resource is saved to non-volatile storage in an implementation-specific matter by the server. There is no guarantee that configuration changes are saved immediately, or that the saved configuration is always a mirror of the running configuration.

Applications which need more control over the persistence model might consider using NETCONF instead of RESTCONF.

2.4.4.5. Defaults Model

NETCONF has a rather complex model for handling default values for leafs. RESTCONF attempts to avoid this complexity by restricting the operations that can be applied to a resource.

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

If the target of a GET method (plus "select" value) is a data node that represents a container or list that has any fields with default values, for the fields that have not been given value yet, the server MAY return the default values that are in use by the server.

Applications which need more control over the defaults model might consider using NETCONF instead of RESTCONF.

2.5. Transaction Model

The RESTCONF protocol provides a simplified transaction model that uses plain REST operations to edit one resource (and sub-resources) at a time. It also provides YANG Patch, which is a standard PATCH method using a new media type (application/yang.patch). This allows a full set of edit operations that can be applied to multiple resources at once.

RESTCONF does not provide a more complex transaction model that allows for multiple edits to be stored in a temporary scratchpad and committed all at once, after one or more edit operations have been done.

Applications which need more control over the transaction model might consider using NETCONF instead of RESTCONF.

2.6. Extensibility Model

The RESTCONF protocol is designed to be extensible for datastore content and data-model specific protocol operations.

Separate namespaces for each YANG module are used. Content encoded in XML will indicate the module using the "namespace" URI value in the YANG module. Content encoded in JSON will indicate the module using the module name specified in the YANG module, but this is not required unless multiple sibling nodes have the same YANG identifier name. JSON encoding rules for module names are specified in [\[I-D.lhotka-netmod-json\]](#).

2.7. Versioning Model

The version of a resource instance is identified with an entity tag, as defined by HTTP. The version identifiers in this section apply to the version of the schema definition of a resource. There are two types of schema versioning information used in the RESTCONF protocol:

- o the RESTCONF protocol version

- o data and operation resource definition versions

The protocol version is identified by the string used for the well-known URI entry point `"/restconf"`. This would be changed (e.g., `"/restconf2"`) if non-backward compatible changes are ever needed. Version changes that do not break backward-compatibility will not cause the entry point to change.

The field `"/restconf/version"` in the API resource can be used by the client to identify the exact version of the RESTCONF protocol implemented by the server.

The resource definition version for a data or operation resource is a date string, which is the revision date of the YANG module that defines the resource. The resource version for all other resource types is the numeric string defined by the `"/restconf/version"` field.

2.8. Retrieval Filtering Model

There are three types of filtering for retrieval of data resources in the RESTCONF protocol.

- o conditional all-or-nothing: use some conditional test mechanism in the request headers and retrieve either a complete "200 OK" response if the condition is met, or a "304 Not Modified" Status-Line if the condition is not met.
- o data classification: request configuration or non-configuration data.
- o filter: request a subset of all possible descendant nodes within the target resource. The "select" query parameter can be used for this purpose.

Refer to [Section 5.3.2](#) for details on data retrieval filtering.

2.9. Access Control Model

The RESTCONF protocol provides granular access control for operation and data resources using the NETCONF Access Control Model (NACM) [[RFC6536](#)]. There is a specific mapping between RESTCONF operations and NETCONF edit operations, defined in Table 1. The resource path also 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.

3. 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")
PUT	<edit-config> (operation="replace")
PATCH	<edit-config> (operation="merge" or <any>)
DELETE	<edit-config> (operation="delete")

Table 1: 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 for a plain PATCH method (using the media type "application/yang.data"). Any operation is possible within a YANG Patch (using the media type "application/yang.patch").

This section defines the RESTCONF protocol usage for each HTTP method.

3.1. OPTIONS

The OPTIONS method is sent by the client to discover which methods are supported by the server for a specific resource. It is supported for all media types. Note that implementation of this method is part of HTTP, and this section does not introduce any additional requirements.

The request MUST contain a request URI that contains at least the entry point component.

The server will return a "Status-Line" header containing "204 No Content". and include the "Allow" header in the response. This header will be filled in based on the target resource media type. Other headers MAY also be included in the response.

Example 1:

A client might request the methods supported for a data resource called "library":

```
OPTIONS /restconf/config/example-jukebox:jukebox/  
library/artist HTTP/1.1  
Host: example.com
```

The server might respond (for a config=true list):

```
HTTP/1.1 204 No Content  
Date: Mon, 23 Apr 2012 17:01:00 GMT  
Server: example-server  
Allow: OPTIONS,HEAD,GET,POST,PUT,PATCH,DELETE
```

Example 2:

A client might request the methods supported for a non-configuration "counters" resource within a "system" resource:

```
OPTIONS /restconf/operational/example-system:system/  
counters HTTP/1.1  
Host: example.com
```

The server might respond:

```
HTTP/1.1 204 No Content  
Date: Mon, 23 Apr 2012 17:02:00 GMT  
Server: example-server  
Allow: OPTIONS,HEAD,GET
```

Example 3:

A client might request the methods supported for an operation resource called "play":

```
OPTIONS /restconf/operations/example-jukebox:play HTTP/1.1  
Host: example.com
```

The server might respond:

```
HTTP/1.1 204 No Content  
Date: Mon, 23 Apr 2012 17:02:00 GMT  
Server: example-server  
Allow: POST
```

3.2. 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 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 component.

The same query parameters supported by the GET method are supported by the HEAD method. For example, the "select" query parameter can be used to specify a nested resource within the target resource.

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 body is included.

Example:

The client might request the response headers for JSON representation of the "library" resource:

```
HEAD /restconf/config/example-jukebox:jukebox/library 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 17:02:40 GMT
Server: example-server
Content-Type: application/yang.data+json
Cache-Control: no-cache
Pragma: no-cache
ETag: a74eefc993a2b
Last-Modified: Mon, 23 Apr 2012 11:02:14 GMT
```

3.3. 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 component.

The following query parameters are supported by the GET method:

Name	Section	Description
depth	3.8.1	Control the depth of a retrieval request
format	3.8.2	Request either JSON or XML content in the response
select	3.8.5	Specify a nested resource within the target resource

GET Query Parameters

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 any portion of the target resource, an error response containing a "403 Forbidden" Status-Line is returned to the client.

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.

Example:

The client might request the response headers for a JSON representation of the "library" resource:

```
GET /restconf/config/example-jukebox:jukebox/  
    library/artist/Foo%20Fighters/album?format=json 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 17:02:40 GMT
Server: example-server
Content-Type: application/yang.data+json
Cache-Control: no-cache
Pragma: no-cache
ETag: a74eefc993a2b
Last-Modified: Mon, 23 Apr 2012 11:02:14 GMT

```

```

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

```

3.4. POST

The POST method is sent by the client for various reasons. The server uses the target resource media type to determine how to process the request.

The request **MUST** contain a request URI that contains a target resource which identifies one of the following resource types:

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

Resource Types that Support POST

3.4.1. 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 resource or sub-resource.

The following query parameters are supported by the POST method for Datastore and Data resource types. They can only be used for YANG list data nodes which are ordered by the user.

Name	Section	Description
insert	3.8.3	Specify where to insert a resource
point	3.8.4	Specify the insert point for a resource

POST Query Parameters

If the POST method succeeds, a "204 No Content" Status-Line is returned and there is no response message body.

If the user is not authorized to create the target resource, 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 6](#).

3.4.2. 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 5.4](#) for details on operation resources.

If the POST method 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 6](#).

3.5. PUT

The PUT method is sent by the client to replace the target resource.

The request **MUST** contain a request URI that contains a target resource that identifies the data resource to replace. If the resource instance does not exist, the server **MAY** create it.

If the PUT method succeeds, a "200 OK" Status-Line is returned, and there is no response message body.

If the user is not authorized to replace the target resource 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 6](#).

3.6. PATCH

The PATCH method uses the HTTP PATCH method defined in [RFC5789] to provide an extensible framework for resource patching mechanisms. Each patch type needs a unique media type. Any number of patch types can be supported by the server. There are two mandatory patch types that MUST be implemented by the server:

- o plain patch type: If the specified media type is "application/yang.data", then the PATCH method is a simple merge operation on the target resource. The message body contains the XML or JSON encoded resource content that will be merged with the target resource.
- o YANG Patch type: If the specified media type is "application/yang.patch", then the PATCH method is a YANG Patch formatted list of edits (see Section 7). The message body contains the XML or JSON encoded instance of the 'patch' container specified in the 'ietf-restconf' YANG module (see Section 8).

The PATCH method MUST be used to create or delete an optional field within an existing resource or sub-resource. If the resource instance does not exist, the server MUST NOT create it.

If the PATCH method succeeds, a "200 OK" Status-Line is returned, and there is no response message body.

If the user is not authorized to alter the target resource 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 6.

3.7. DELETE

The DELETE method is used to delete the target resource.

If the DELETE method succeeds, a "200 OK" 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 is returned to the client. All other error responses are handled according to the procedures defined in Section 6.

3.8. Query Parameters

Each RESTCONF operation allows zero or more query parameters to be present in the request URI. Refer to Section 3 for details on the

query parameters used in the definition of each operation.

Query parameters can be given in any order. Each parameter can appear zero or one time. A default value may apply if the parameter is missing.

This section defines all the RESTCONF query parameters.

3.8.1. "depth" Parameter

The "depth" parameter is used to specify the number of nest levels returned in a response for a GET method. A nest-level consists of the target resource and any child nodes which are contained within the target resource node.

The start level is determined by the target resource for the operation.

```
syntax: depth=<range: 1..max> | unbounded
default: unbounded
```

Example:

This example operation would retrieve 2 levels of configuration data nodes that exist within the top-level "jukebox" resource.

```
GET /restconf/config/example-jukebox:jukebox
    ?depth=2 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"
      }
    },
    "player" : {
      "gap" : 0.5
    }
  }
}
```

By default, the server will include all sub-resources within a retrieved resource, which have the same resource type as the requested resource. Only only level of sub-resources with a different media type than the target resource will be returned.

For example, if the client retrieves the "application/yang.api" resource type, then the node for the datastore resource is returned as an empty node, because all its child nodes are data resources. The entire contents of the datastore are not returned in this case. The operation resources are also returned as empty nodes (e.g. "play" operation).

Request URL:

```
GET /restconf HTTP/1.1
```

Response:


```
{
  "ietf-restconf:restconf": {
    "config" : [ null ],
    "operational" : [ null ],
    "modules": {
      "module": [
        {
          "name" : "example-jukebox",
          "revision" : "2013-10-19",
          "namespace" : "http://example.com/ns/example-jukebox"
        }
      ]
    },
    "operations" : {
      "play" : [ null ]
    },
    "version": "1.0"
  }
}
```

3.8.2. "format" Parameter

The "format" parameter is used to specify the format of any content returned in the response. Note that this parameter MAY be used instead of the "Accept" header to identify the format desired in the response.

The "format" parameter is only supported for the GET and HEAD methods. It is supported for all RESTCONF media types.

syntax: format= xml | json
default: Accept header, then xml

If the "format" parameter is present, then it overrides the Accept header, if present. If neither the Accept header or the "format" parameter are present, then the default is XML.

Examples:

```
GET /restconf/config/example-routing:routing HTTP/1.1
Host: example.com
Accept: application/yang.data+json
```

This example request would retrieve only the configuration data nodes that exist within the top-level "routing" resource, and retrieve them in JSON encoding.

```
GET /restconf/config/example-routing:routing?
    format=json HTTP/1.1
Host: example.com
```

This example request would retrieve only the configuration data nodes that exist within the top-level "routing" resource, and retrieve them in JSON encoding.

3.8.3. "insert" Parameter

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

This parameter is only supported for the POST method. It is also only supported if the target resource is a data resource, and that data represents a YANG list that is ordered by the user, not the system.

If the values "before" or "after" are used, then a "point" parameter for the insertion parameter MUST also be present.

```
syntax: insert= first | last | before | after
default: last
```

Example:

Request from client:

```
POST /restconf/config/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: http://example.com/restconf/config/
  example-jukebox:jukebox/playlist/Foo-One/song/1
ETag: eeeada438af
```

3.8.4. "point" Parameter

The "point" parameter is used to specify the insertion point for a data resource that is being created or moved within a user ordered list. It is ignored unless the "insert" query parameter is also present, and has the value "before" or "after".

This parameter contains the instance identifier of the resource to be used as the insertion point for a POST method. It is encoded according to the rules defined in [Section 5.3.1](#). There is no default for this parameter.

Note that the first path component encoded for an instance identifier is the top-level YANG data node. The "/restconf/config" entry point is not included in an instance-identifier.

syntax: point= <instance-identifier of insertion point node>

Example:

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

{
  "example-jukebox:song" : {
    "name" : "Rope",
    "location" : "/media/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
```

3.8.5. "select" Parameter

The "select" query parameter is used to specify an expression which can represent a subset of all data nodes within the target resource. It contains a relative path expression, using the target resource as the context node.

It is supported for all resource types except operation resources. The contents are encoded according to the "api-select" rule defined in [Section 5.3.1](#). This parameter is only allowed for GET and HEAD methods.

[FIXME: the syntax of the select string is still TBD; XPath, schema-identifier, regular expressions, something else; Perhaps add parameter "xselect" for XPath and this param is limited to a path-expr.]

In this example the client is retrieving the API version field from the server in JSON format:

```
GET /restconf?select=version&format=json 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
Cache-Control: no-cache
Pragma: no-cache
Last-Modified: Sun, 22 Apr 2012 01:00:14 GMT
Content-Type: application/yang.api+json

{ "ietf-restconf:version": "1.0" }
```

3.9. Protocol Operations

The RESTCONF protocol allows data-model specific protocol operations to be invoked using the POST method. The media type "application/yang.operation+xml" or "application/yang.operation+json" MUST be used in the "Content-Type" line in the message header.

Data model specific operations are supported. The syntax and semantics of these operations exactly correspond to the YANG "rpc" statement definition for the operation.

Refer to [Section 5.4](#) for details on operation resources.

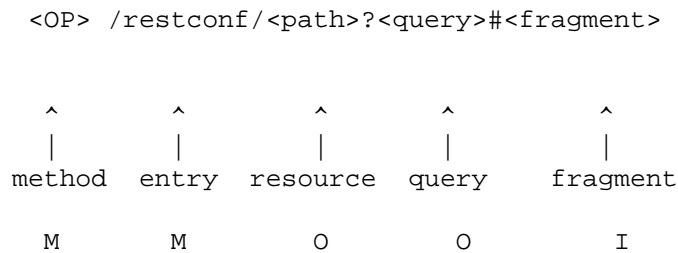
4. Messages

This section describes the messages that are used in the RESTCONF protocol.

4.1. 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:



M=mandatory, O=optional, I=ignored

<text> replaced by client with real values

- 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 3](#).
- o entry: the well-known RESTCONF entry point ("/restconf").
- o 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".
- o query: the set of parameters associated with the RESTCONF message. These have the familiar form of "name=value" pairs. There is a specific set of parameters defined, although the server MAY choose to support additional parameters not defined in this document. The contents of the any query parameter value MUST be encoded according to [\[RFC2396\]](#), [section 3.4](#). Any reserved characters MUST be encoded with escape sequences, according to [\[RFC2396\]](#), [section 2.4](#).

- o 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 **MUST** use 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.

4.2. Message Headers

There are several HTTP header lines utilized in RESTCONF messages. Messages are not limited to the HTTP headers listed in this section.

HTTP defines which header lines are required for particular circumstances. Refer to each operation definition section in [Section 3](#) for examples on how particular headers are used.

There are some request headers that are used within RESTCONF, usually applied to data resources. The following tables summarize the headers most relevant in RESTCONF message requests:

Name	Description
Accept	Response Content-Types that are acceptable
Content-Type	The media type of the request body
Host	The host address of the server
If-Match	Only perform the action if the entity matches ETag
If-Modified-Since	Only perform the action if modified since time
If-Unmodified-Since	Only perform the action if un-modified since time

RESTCONF Request Headers

The following tables summarize the headers most relevant in RESTCONF message responses:

Name	Description
Allow	Valid actions when 405 error returned
Cache-Control	The cache control parameters for the response
Content-Type	The media type of the response body
Date	The date and time the message was sent
ETag	An identifier for a specific version of a resource
Last-Modified	The last modified date and time of a resource
Location	The resource identifier for a newly created resource

RESTCONF Response Headers

4.3. Message Encoding

RESTCONF messages are encoded in HTTP according to [RFC 2616](#). 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.

XML encoding rules for data nodes are defined in [\[RFC6020\]](#). The same encoding rules are used for all XML content.

JSON encoding rules are defined in [\[I-D.lhotka-netmod-json\]](#). Plain JSON cannot be used because special encoding rules are needed to handle multiple module namespaces and provide consistent data type processing.

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.

Response output content encoding format is identified with the Accept header, the "format" query parameter, or if neither is specified, the request input encoding format is used. If there was no request input, then the default output encoding is XML. File extensions encoded in the request are not used to identify format encoding.

4.4. 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, but JSON does not have a standard way of attaching non-schema defined meta-data to a resource or field.

4.4.1. JSON Encoding of RESTCONF Meta-Data

The YANG to JSON mapping [[I-D.lhotka-netmod-json](#)] does not support attributes because YANG does not support meta-data in data node definitions. This section specifies how RESTCONF meta-data is encoded in JSON.

Only simple meta-data is supported:

- o A meta-data instance can appear 0 or 1 times for a particular data node
- o A meta-data instance associated with a resource is encoded as if it were a YANG leaf of type "string", according to the encoding rules in [[I-D.lhotka-netmod-json](#)], except the identifier is prepended with a "@" (%40) character.
- o A meta-data instance associated with a field within a resource is encoded as if it were a container for the meta-data values and the field value in its native encoding. It is encoded according to the rules in [[I-D.lhotka-netmod-json](#)], except the meta-data identifiers are prepended with a "@" (%40) character. The field name/value pair is repeated inside this container, which contains the actual value of the field.

Examples:

Meta-data:

```
enabled=<boolean>
owner=<owner-name>
```

YANG module: example

YANG example:

```
container top {
  leaf A {
    type int32;
  }
  leaf B {
    type boolean;
  }
}
```

The client is retrieving the "top" data resource, and the server is including datastore meta-data. Note that a query parameter to request or suppress specific meta-data is not provided in RESTCONF.

```
GET /restconf/config/example:top 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:top": {
    "@enabled" : "true",
    "@owner" : "fred",
    "A" : {
      "@enabled" : "true",
      "A" : 42
    },
    "B" : {
      "@enabled" : "false",
      "B" : true
    }
  }
}
```

4.5. 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 6.1](#).

4.6. 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 using 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.

5. Resources

The resources used in the RESTCONF protocol are identified by the "path" component in the request URI. Each operation is performed on a target resource.

5.1. API Resource (/restconf)

The API resource contains the state and access points for the RESTCONF features. It is the top-level resource and has the media type "application/yang.api+xml" or "application/yang.api+json". It is accessible through the well-known relative URI "/restconf".

YANG Tree Diagram for "application/yang.api" Resource Type:

```

+--rw restconf
|   +--rw config
|   +--rw operational
|   +--rw modules
|       +--rw module [name revision]
|           +--rw name          yang:yang-identifier
|           +--rw revision      union
|           +--rw namespace     inet:uri
|           +--rw feature*      yang:yang-identifier
|           +--rw deviation*    yang:yang-identifier
|       +--rw operations
|       +--rw streams
|           +--rw stream [name]
|               +--rw name          string
|               +--rw description?  string
|               +--rw replay-support? boolean
|               +--rw replay-log-creation-time? yang:date-and-time
|               +--rw events?      empty
|       +--ro version?      enumeration
+--rw notification
    +--rw event-time        yang:date-and-time

```

The "restconf" container definition in the "ietf-restconf" module defined in [Section 8](#) is used to specify the structure and syntax of the conceptual fields and sub-resources within the API resource.

The "restconf" entry point container, and all fields and sub-resources with the same resource type, are defined in the namespace of the "ietf-restconf" module.

There is one mandatory field "version" that identifies the specific version of the RESTCONF protocol implemented by the server:

- o The same server-wide response MUST be returned each time this field is retrieved.
- o It is assigned by the server when the server is started.
- o The server MUST return the value "1.0" for this version of the RESTCONF protocol.
- o This field is encoded with the rules for an "enumeration" data type, using the "version" leaf definition in [Section 8](#).

This resource has the following child resources:

Child Resource	Description
datastore	Link to "datastore" resource
modules	YANG module capability URIs
operations	Data-model specific operations
streams	Notification event streams

RESTCONF Resources

5.1.1. /restconf/config

This mandatory resource represents the running configuration datastore. It contains configuration data resources that may be retrieved and edited by a client. It cannot be created or deleted by a client. This resource type is defined in [Section 5.2](#).

5.1.2. /restconf/operational

This mandatory resource represents the operational datastore. It contains operational data and statistics data resources that may be retrieved by a client. It cannot be created or deleted by the client. This resource type is defined in [Section 5.2](#).

Example:

This example request by the client would retrieve only the non-configuration data nodes that exist within the "library" resource.

```
GET /restconf/operational/example-jukebox:jukebox/library
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 17:01:30 GMT
Server: example-server
Cache-Control: no-cache
Pragma: no-cache
Content-Type: application/yang.data+json
```

```
{
  "example-jukebox:library" : {
    "artist-count" : 42,
    "album-count" : 59,
    "song-count" : 374
  }
}
```

5.1.3. /restconf/modules

This mandatory resource contains the identifiers for the YANG data model modules supported by the server.

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

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

5.1.3.1. /restconf/modules/module

This mandatory resource contains one list entry for each YANG data model module supported by the server. There **MUST** be an instance of this resource for every YANG module that is accessible via an operation resource or a data resource.

The contents of the "module" resource are defined in the "module" YANG list statement in [Section 8](#).

The server **MAY** maintain a last-modified timestamp for each instance of this resource, and return the "Last-Modified" header when this resource is retrieved with the GET or HEAD methods. If not supported then the timestamp for the parent "modules" resource **MAY** be used instead.

The server **MAY** maintain an entity-tag for each instance of this resource, and return the "ETag" header when this resource is

retrieved with the GET or HEAD methods. If not supported then the timestamp for the parent "modules" resource MAY be used instead.

5.1.3.2. Retrieval Example

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

```
GET /restconf/modules&format=json 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
Cache-Control: no-cache
Pragma: no-cache
Last-Modified: Sun, 22 Apr 2012 01:00:14 GMT
Content-Type: application/yang.api+json

{
  "ietf-restconf:modules": {
    "module": [
      {
        "name" : "foo",
        "revision" : "2012-01-02",
        "namespace" : "http://example.com/ns/foo",
        "feature" : [ "feature1", "feature2" ]
      },
      {
        "name" : "foo-types",
        "revision" : "2012-01-05",
        "namespace" : "http://example.com/ns/foo-types"
      },
      {
        "name" : "bar",
        "revision" : "2012-11-05",
        "namespace" : "http://example.com/ns/bar",
        "feature" : [ "bar-ext" ]
      }
    ]
  }
}
```

5.1.4. /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 operations defined in the YANG modules advertised by the server MAY be available as child nodes of this resource.

Refer to [Section 5.4](#) for details on operation resources.

5.1.5. /restconf/streams

This optional resource is a container that provides access to the notification event streams supported by the server. The server MAY omit this resource if no notification event streams are supported. The media type for this resource is "application/yang.api".

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 represents an event stream resource. The media type for this resource is "application/yang.stream". Refer to [Section 2.2](#) for details on notifications.

5.2. Datastore Resource

A datastore resource represents the conceptual root of a tree of data resources. The media type for this resource is "application/yang.datastore". A datastore resource can be retrieved with the GET method.

The server MUST maintain a last-modified timestamp for this resource, and return the "Last-Modified" header when this resource is retrieved with the GET or HEAD methods. Only changes to configuration data resources within the datastore affect this timestamp.

The server MUST maintain a resource entity tag for this resource, and return the "ETag" header when this resource is retrieved with the GET or HEAD methods. The resource entity tag MUST be changed to a new previously unused value if changes to any configuration data resources within the datastore are made.

The depth of the subtrees returned in retrieval operations can be controlled with the "depth" query parameter. The number of nest levels, starting at the target resource, can be specified, or an unlimited number can be returned. Refer to [Section 3.8.1](#) for more

details.

A datastore resource can only be written directly with the PATCH method. Only the configuration data resources within the datastore resource can be edited directly with all methods.]

5.3. Data Resource

A data resource represents a YANG data node that is a descendant node of a datastore resource. Only YANG container and list data node types are considered to represent data resources. Other YANG data nodes are considered to be fields within their parent resource.

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.

For configuration data resources, the server MAY 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 changed to a new previously unused value if changes to the resource or any configuration resource within the resource is altered.

A data resource can be retrieved with the GET method. Configuration data resources can be accessed via the "/restconf/config" entry point. Operational data resources can be accessed via the "/restconf/operational" entry point.

The depth of the subtrees returned in retrieval operations can be controlled with the "depth" query parameter. The number of nest levels, starting at the target resource, can be specified, or an unlimited number can be returned. Refer to [Section 3.8.1](#) for more details.

A configuration data resource can be altered by the client with some of all of the edit operations, depending on the target resource and the specific operation. Refer to [Section 3](#) for more details on edit operations.

5.3.1. Encoding YANG Instance Identifiers in the Request URI

In YANG, data nodes are named with an absolute XPath expression, from the document root to the target resource. In RESTCONF, URL friendly path expressions are used instead.

The YANG "instance-identifier" (i-i) data type is represented in RESTCONF with the path expression format defined in this section.

+-----+-----+-----+-----+-----+-----+	
Name Comments	
+-----+-----+-----+-----+-----+-----+	
point	Insertion point is always a full i-i
path	Request URI path is a full or partial i-i
+-----+-----+-----+-----+-----+-----+	

RESTCONF instance-identifier Type Conversion

The "path" component of the request URI contains the absolute path expression that identifies the target resource. The "select" query parameter is used to optionally identify the requested data nodes within the target resource to be retrieved in a GET method.

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 5.3.1.1](#). 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 the "select" is present, it is encoded, starting with a child node of the target resource, according to the "api-select" rule defined in [Section 5.3.1.1](#).

If a data node in the path expression is a YANG list node, then the key values for the list (if any) are encoded according to the "key-value" rule. If the list node is the target resource, then the key values MAY be omitted, according to the operation. For example, the POST method to create a new data resource for a list node does not allow the key values to be present in the request URI.

The key leaf values for a data resource representing a YANG list MUST be encoded as follows:

- o The value of each leaf identified in the "key" statement is encoded in order.
- o All the components in the "key" statement MUST be encoded. Partial instance identifiers are not supported.
- o Each value is encoded using the "key-value" rule in [Section 5.3.1.1](#), according to the encoding rules for the data type of the key leaf.

- o An empty string can be a valid key value (e.g., "/top/list/key1//key3").
- o The "/" character MUST be URL-encoded (i.e., "%2F").
- o All whitespace MUST be URL-encoded.
- o A "null" value is not allowed since the "empty" data type is not allowed for key leafs.
- o The XML encoding is defined in [RFC6020].
- o The JSON encoding is defined in [I-D.lhotka-netmod-json].
- o The entire "key-value" MUST be properly URL-encoded, according to the rules defined in [RFC3986].
- o 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:

```
[ lines wrapped for display purposes only ]

/restconf/config/example-jukebox:jukebox/library/
  artist/Beatles&select=album

/restconf/config/example-list:newlist/17&
  select=nextlist%2Ffoo%2Fbar%2Facme-list-ext%3Aext-leaf

/restconf/config/example-list:somelist/the%20key

/restconf/config/example-list:somelist/the%20key/address
```

5.3.1.1. ABNF For Data Resource Identifiers

The following ABNF syntax is used to construct RESTCONF path identifiers:

```

api-path = "/" |
           ("/" api-identifier
            0*("/" (api-identifier | key-value )))

[FIXME: the syntax for the select string is still TBD]
api-select = api-identifier
            0*("/" (api-identifier | key-value ))

api-identifier = [module-name ":" ] identifier

module-name = identifier

key-value = string

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

string = <an unquoted string>

```

5.3.2. Data Resource Retrieval

There are three types of filtering for retrieval of data resources. This section defines each mode.

5.3.2.1. Conditional Retrieval

The HTTP headers (such as "If-Modified-Since" and "If-Match") can be used in for a request message for a GET method to check a condition within the server state, such as the last time the datastore resource was modified, or the resource entity tag of the target resource.

If the condition is met according to the header definition, a "200 OK" Status-Line and the data requested is returned in the response message. If the condition is not met, a "304 Not Modified" Status-Line is returned in response message instead.

5.3.2.2. Data Classification Retrieval

The "/restconf/config" datastore resource is used to access child configuration data resources. The "/restconf/operational" datastore resource is used to access child operational data resources.

5.3.2.3. Filtered Retrieval

The "select" query parameter is used to specify a filter that should be applied to the target resource to request a subset of all possible

descendant nodes within the target resource.

The format of the "select" parameter string is defined in [Section 3.8.5](#). The set of nodes selected by the filter expression is applied to each context node identified by the target resource.

5.4. Operation Resource

An operation resource represents an protocol operation defined with the YANG "rpc" statement.

All operation resources share the same module namespace as any top-level data resources, so the name of an operation resource cannot conflict with the name of a top-level data resource defined within the same module.

If 2 different YANG modules define the same "rpc" identifier, then the module name MUST be used in the request URI. For example, if "module-A" and "module-B" both defined a "reset" 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
```

Any usage of an operation resource from the same module, with the same name, refers to the same "rpc" statement definition. This behavior can be used to design protocol operations that perform the same general function on different resource types.

If the "rpc" 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 "rpc" statement has an "output" section, then a message body MAY be sent by the server in the response. Otherwise the server MUST NOT include a message body in the response message, and MUST send a "204 No Content" Status-Line instead.

5.4.1. Encoding Operation Input Parameters

If the "rpc" 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.

Example:

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

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

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.data+json
```

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

The server might respond:

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

5.4.2. Encoding Operation Output Parameters

If the "rpc" 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.

Example:

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

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

The client might send the following POST request message:

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

The server might respond:

```
HTTP/1.1 200 OK  
Date: Mon, 25 Apr 2012 11:10:30 GMT  
Server: example-server
```

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

5.5. Stream Resource

A 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 2.2.3](#).

A notification stream functions according to the NETCONF Notifications specification [[RFC5277](#)]. The "ietf-restconf" YANG module contains the "stream" list (/restconf/streams/stream) which specifies the syntax and semantics of a stream resource.

6. 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 body
201 Created	POST to create a resource success
202 Accepted	POST to create a resource accepted
204 No Content	Success without response body
304 Not Modified	Conditional operation not done
400 Bad Request	Invalid request message
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, 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 "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

6.1. Error Response Message

When an error occurs for a request message on a data resource or an operation resource, and a "4xx" class of status codes (except for status code "403"), then the server SHOULD send a response body containing the information described by the "errors" container definition within the YANG module [Section 8](#).

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?     data-resource-identifier
    +--ro error-message?  string
    +--ro error-info

```

Example:

The following example shows an error returned for an "lock-denied"

error on a datastore resource.

```
POST /restconf/operations/example-ops:lock-datastore HTTP/1.1
Host: example.com
```

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.api+json
```

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

7. YANG Patch

The YANG Patch operation is provided so complex editing operations can be performed within RESTCONF. The "plain patch" operation only provides a simple merge edit operation on the target datastore.

A "YANG Patch" is an ordered list of edits that are applied to the target datastore by the server. The specific fields are defined with the 'yang-patch' container definition in the YANG module [Section 8](#).

The YANG Patch operation is selected by the client by invoking a PATCH method with the YANG Patch media type. A message body representing the YANG Patch input parameters MUST be provided.

Each patch is identified by a client provided string, called the "patch-id".

YANG Tree Diagram For "application/yang.patch" Media Type

```
+--rw yang-patch
|  +--rw patch-id?   string
|  +--rw comment?   string
|  +--rw edit [edit-id]
|      +--rw edit-id       string
|      +--rw operation     enumeration
|      +--rw target        data-resource-identifier
|      +--rw point?        data-resource-identifier
|      +--rw where?        enumeration
|      +--rw value
```

A data element representing the YANG Patch Status is returned to the client to report the detailed status of the edit operation. This data is identified by the YANG Patch Status media type.

YANG Tree Diagram For "application/yang.patch-status" Media Type:

```

+--rw yang-patch-status
  +--rw patch-id?          string
  +--rw (global-status)?
  |   +--:(global-errors)
  |   |   +--ro errors
  |   |
  |   +--:(ok)
  |   |   +--rw ok?          empty
  +--rw edit-status
    +--rw edit [edit-id]
      +--rw edit-id        string
      +--rw (edit-status-choice)?
      |   +--:(ok)
      |   |   +--rw ok?          empty
      |   +--:(location)
      |   |   +--rw location?    inet:uri
      |   +--:(errors)
      |   |   +--ro errors

```

7.1. Why not use JSON Patch?

The HTTP PATCH method requires that the media type of the patch content be specified, so it should be possible to use any patch mechanism, including JSON Patch [RFC6902].

The RESTCONF protocol is designed to utilize the YANG data modeling language to specify content schemas. The JSON Patch mechanism is incompatible with RESTCONF for the following reasons:

- o A patch mechanism that works with either XML or JSON encoding is needed.
- o YANG configuration nodes can be named with complex keys, using one or more key leafs. JSON arrays are packed and all the YANG keys would be collapsed down to a single integer index.
- o YANG configuration nodes are named with stable, persistent identifiers, using key leafs. JSON arrays are packed, and if entry I is added or deleted, then all entries I+1 .. I_{max} are renumbered.
- o The edit operation set needs to align with the NETCONF protocol, and JSON Patch does not provide an aligned set of edit operations.
- o The datastore validation procedures need to be specific and aligned with YANG validation procedures.

- o The error reporting needs to align with the NETCONF protocol, and JSON Patch does not provide an aligned error reporting mechanism.

7.2. YANG Patch Target Data Node

The target data node for each edit operation is determined by the value of the target resource in the request and the "target" leaf within each "edit" entry.

If the target resource specified in the request URI identifies a datastore resource, then the path string in the "target" leaf is an absolute path expression. The first node specified in the "target" leaf is a top-level data node defined within a YANG module.

If the target resource specified in the request URI identifies a data resource, then the path string in the "target" leaf is a relative path expression. The first node specified in the "target" leaf is a child node of the data node associated with the target resource.

7.3. YANG Patch Edit Operations

Each YANG patch edit specifies one edit operation on the target data node. The set of operations is aligned with the NETCONF edit operations, but also includes some new operations.

Operation	Description
create	create a new data resource if it does not already exist or error
delete	delete a data resource if it already exists or error
insert	insert a new user-ordered data resource
merge	merge the edit value with the target data resource; create if it does not already exist
move	re-order the target data resource
replace	replace the target data resource with the edit value
remove	remove a data resource if it already exists or no error

YANG Patch Edit Operations

7.4. YANG Patch Error Handling

If a well-formed, schema-valid YANG Patch message is received, then then the server will process the supplied edits in ascending order. The following error modes apply to the processing of this edit list:

All the specified edits MUST be applied or the target datastore contents SHOULD be returned to its original state before the PATCH method started. The server MAY fail to restore the contents of the target datastore completely and with certainty. It is possible for a rollback to fail or an "undo" operation to fail.

The server will save the running datastore to non-volatile storage if it has changed, after the edits have been attempted.

7.5. YANG Patch Response

A special response is returned for YANG Patch operations, in order to report status information for each individual edit. It is possible to report general errors as well. The YANG conceptual container definition "yang-patch-status" defined in [Section 8](#) defines the syntax.

7.6. YANG Patch Examples

7.6.1. Add Resources: Error

The following example shows several songs being added to an existing album. Each edit contains one song. The first song already exists, so an error will be reported for that edit. The rest of the edits were not attempted, since the first edit failed.

Request from client:

```
PATCH /restconf/config/example-jukebox:jukebox/
      library/artist/Foo%20Fighters/album/Wasting%20Light HTTP/1.1
Host: example.com
Accept: application/yang.patch-status+json
Content-Type: application/yang.patch+json
```

```
{
  "ietf-restconf:yang-patch" : {
    "patch-id" : "add-songs-patch",
    "edit" : [
      {
        "edit-id" : 1,
        "operation" : "create",
        "target" : "/song",
        "value" : {
          "song" : {
            "name" : "Bridge Burning",
            "location" : "/media/bridge_burning.mp3",
            "format" : "MP3",
            "length" : 288
          }
        }
      }
    ]
  }
}
```

```

    }
  },
  {
    "edit-id" : 2,
    "operation" : "create",
    "target" : "/song",
    "value" : {
      "song" : {
        "name" : "Rope",
        "location" : "/media/rope.mp3",
        "format" : "MP3",
        "length" : 259
      }
    }
  },
  {
    "edit-id" : 3,
    "operation" : "create",
    "target" : "/song",
    "value" : {
      "song" : {
        "name" : "Dear Rosemary",
        "location" : "/media/dear_rosemary.mp3",
        "format" : "MP3",
        "length" : 269
      }
    }
  }
]
}

```

Response from server:

```

HTTP/1.1 409 Conflict
Date: Mon, 23 Apr 2012 13:01:20 GMT
Server: example-server
Last-Modified: Mon, 23 Apr 2012 13:01:20 GMT
Content-Type: application/yang.patch-status+json

```

```

{
  "ietf-restconf:yang-patch-status" : {
    "patch-id" : "add-songs-patch",
    "edit-status" : {
      "edit" : [
        {
          "edit-id" : 1,

```

```

    "errors" : {
      "error" : [
        {
          "error-type": "application",
          "error-tag": "data-exists",
          "error-path": "/example-jukebox:jukebox/library
                        /artist/Foo%20Fighters/album/Wasting%20Light
                        /song/Burning%20Light",
          "error-message":
            "Data already exists, cannot be created"
        }
      ]
    }
  }
}

```

7.6.2. Add Resources: Success

The following example shows several songs being added to an existing album.

- o Each of 2 edits contains one song.
- o Both edits succeed and new sub-resources are created

Request from client:

```

PATCH /restconf/config/example-jukebox:jukebox/
      library/artist/Foo%20Fighters/album/Wasting%20Light
      HTTP/1.1
Host: example.com
Accept: application/yang.patch-status+json
Content-Type: application/yang.patch+json

{
  "ietf-restconf:yang-patch" : {
    "patch-id" : "add-songs-patch-2",
    "edit" : [
      {
        "edit-id" : 1,
        "operation" : "create",
        "target" : "/song",
        "value" : {
          "song" : {

```



```

        "name" : "Rope",
        "location" : "/media/rope.mp3",
        "format" : "MP3",
        "length" : 259
      }
    },
    {
      "edit-id" : 2,
      "operation" : "create",
      "target" : "/song",
      "value" : {
        "song" : {
          "name" : "Dear Rosemary",
          "location" : "/media/dear_rosemary.mp3",
          "format" : "MP3",
          "length" : 269
        }
      }
    }
  ]
}

```

Response from server:

```

HTTP/1.1 409 Conflict
Date: Mon, 23 Apr 2012 13:01:20 GMT
Server: example-server
Last-Modified: Mon, 23 Apr 2012 13:01:20 GMT
Content-Type: application/yang.patch-status+json

{
  "ietf-restconf:yang-patch-status" : {
    "patch-id" : "add-songs-patch-2",
    "ok" : [null],
    "edit-status" : {
      "edit" : [
        {
          "edit-id" : 1,
          "location" : "http://example.com/restconf/
            config/example-jukebox:jukebox/library/artist/
            Foo%20Fighters/album/Wasting%20Light/song/Rope"
        },
        {
          "edit-id" : 2,
          "location" : "http://example.com/restconf/
            config/example-jukebox:jukebox/library/artist/

```

```
        Foo%20Fighters/album/Wasting%20Light/song/  
        Dear%20Rosemary"  
    }  
  ]  
}  
}  
}
```

7.6.3. Move list entry example

The following example shows a song being moved within an existing playlist. Song "1" in playlist "Foo-One" is being moved after song "3" in the playlist. The operation succeeds, so a non-error reply example can be shown.

Request from client:

```
PATCH /restconf/config/example-jukebox:jukebox/
      playlist/Foo-One HTTP/1.1
Host: example.com
Accept: application/yang.patch-status+json
Content-Type: application/yang.patch+json

{
  "ietf-restconf:yang-patch" : {
    "patch-id" : "move-song-patch",
    "comment" : "Move song 1 after song 3",
    "edit" : [
      {
        "edit-id" : 1,
        "operation" : "move",
        "target" : "/song/1",
        "point" : "/song3",
        "where" : "after"
      }
    ]
  }
}
```

Response from server:

```
HTTP/1.1 400 OK
Date: Mon, 23 Apr 2012 13:01:20 GMT
Server: example-server
Last-Modified: Mon, 23 Apr 2012 13:01:20 GMT
Content-Type: application/yang.patch-status+json

{
  "ietf-restconf:yang-patch-status" : {
    "patch-id" : "move-song-patch",
    "ok" : [null],
    "edit-status" : {
      "edit" : [
        {
          "edit-id" : 1,
          "ok" : [ null ]
        }
      ]
    }
  }
}
```

8. RESTCONF module

The "ietf-restconf" module defines conceptual definitions within groupings, which are not meant to be implemented as datastore contents by a server.

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@2013-10-19.yang"

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

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

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

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

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

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

      Editor:   Rex Fernando
      <mailto:rex@cisco.com>";

  description
    "This module contains conceptual YANG specifications
    for the YANG Patch and error content that is used in
    RESTCONF protocol messages. A conceptual container
    representing the RESTCONF API nodes (media type
    application/yang.api).

    Note that the YANG definitions within this module do not
    represent configuration data of any kind.
    The YANG grouping statements provide a normative syntax
    for XML and JSON message encoding purposes."
```

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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-bierman-netconf-restconf-02.txt

// RFC Ed.: update the date below with the date of RFC publication
// and remove this note.
revision 2013-10-19 {
  description
    "Initial revision.";
  reference
    "RFC XXXX: RESTCONF Protocol.";
}

typedef data-resource-identifier {
  type string {
    length "1 .. max";
  }
  description
    "Contains a Data Resource Identifier formatted string
    to identify a specific data node. The data node that
    uses this data type SHOULD define the document root
    for data resource identifiers. The default document
    root is the target datastore conceptual root node.
    Data resource identifiers are defined relative to
    this document root.";
  reference
    "RFC XXXX: [sec. 5.3.1.1 ABNF For Data Resource Identifiers]";
}

// this typedef is TBD; not currently used
typedef datastore-identifier {
  type union {
    type enumeration {
```

```
    enum candidate {
        description
            "Identifies the NETCONF shared candidate datastore.";
        reference
            "RFC 6241, section 8.3";
    }
    enum running {
        description
            "Identifies the NETCONF running datastore.";
        reference
            "RFC 6241, section 5.1";
    }
    enum startup {
        description
            "Identifies the NETCONF startup datastore.";
        reference
            "RFC 6241, section 8.7";
    }
}
type string;
}
description
    "Contains a string to identify a specific datastore.
    The enumerated datastore identifier values are
    reserved for standard datastore names.";
}

typedef revision-identifier {
    type string {
        pattern '\d{4}-\d{2}-\d{2}';
    }
    description
        "Represents a specific date in YYYY-MM-DD format.
        TBD: make pattern more precise to exclude leading zeros.";
}

grouping yang-patch {

    description
        "A grouping that contains a YANG container
        representing the syntax and semantics of a
        YANG Patch edit request message.";

    container yang-patch {
        description
            "Represents a conceptual sequence of datastore edits,
            called a patch. Each patch is given a client-assigned
            patch identifier. Each edit MUST be applied
```

in ascending order, and all edits MUST be applied. If any errors occur, then the target datastore MUST NOT be changed by the patch operation.

A patch MUST be validated by the server to be a well-formed message before any of the patch edits are validated or attempted.

YANG datastore validation (defined in [RFC 6020, section 8.3.3](#)) is performed after all edits have been individually validated.

It is possible for a datastore constraint violation to occur due to any node in the datastore, including nodes not included in the edit list. Any validation errors MUST be reported in the reply message."

reference

"[RFC 6020, section 8.3](#)."

```
leaf patch-id {
  type string;
  description
    "An arbitrary string provided by the client to identify
     the entire patch. This value SHOULD be present in any
     audit logging records generated by the server for the
     patch. Error messages returned by the server pertaining
     to this patch will be identified by this patch-id value."
}

leaf comment {
  type string {
    length "0 .. 1024";
  }
  description
    "An arbitrary string provided by the client to describe
     the entire patch. This value SHOULD be present in any
     audit logging records generated by the server for the
     patch."
}

list edit {
  key edit-id;
  ordered-by user;

  description
    "Represents one edit within the YANG Patch
     request message."
```

```
leaf edit-id {
  type string;
  description
    "Arbitrary string index for the edit.
    Error messages returned by the server pertaining
    to a specific edit will be identified by this
    value.";
}

leaf operation {
  type enumeration {
    enum create {
      description
        "The target data node is created using the
        supplied value, only if it does not already
        exist.";
    }
    enum delete {
      description
        "Delete the target node, only if the data resource
        currently exists, otherwise return an error.";
    }
    enum insert {
      description
        "Insert the supplied value into a user-ordered
        list or leaf-list entry. The target node must
        represent a new data resource.";
    }
    enum merge {
      description
        "The supplied value is merged with the target data
        node.";
    }
    enum move {
      description
        "Move the target node. Reorder a user-ordered
        list or leaf-list. The target node must represent
        an existing data resource.";
    }
    enum replace {
      description
        "The supplied value is used to replace the target
        data node.";
    }
    enum remove {
      description
        "Delete the target node if it currently exists.";
    }
  }
}
```



```
    }
    mandatory true;
    description
      "The datastore operation requested for the associated
      edit entry";
  }

  leaf target {
    type data-resource-identifier;
    mandatory true;
    description
      "Identifies the target data resource for the edit
      operation.";
  }

  leaf point {
    when "(../operation = 'insert' or " +
      "../operation = 'move') and " +
      "(../where = 'before' or ../where = 'after')";
    description
      "Point leaf only applies for insert or move
      operations, before or after an existing entry.";
  }
  type data-resource-identifier;
  description
    "The absolute URL path for the data node that is being
    used as the insertion point or move point for the
    target of this edit entry.";
  }

  leaf where {
    when "../operation = 'insert' or ../operation = 'move'";
    description
      "Where leaf only applies for insert or move
      operations.";
  }
  type enumeration {
    enum before {
      description
        "Insert or move a data node before the data resource
        identified by the 'point' parameter.";
    }
    enum after {
      description
        "Insert or move a data node after the data resource
        identified by the 'point' parameter.";
    }
    enum first {
```

```
        description
          "Insert or move a data node so it becomes ordered
           as the first entry.";
      }
      enum last {
        description
          "Insert or move a data node so it becomes ordered
           as the last entry.";
      }
    }
    default last;
    description
      "Identifies where a data resource will be inserted or
       moved. YANG only allows these operations for
       list and leaf-list data nodes that are ordered-by
       user.";
  }

  anyxml value {
    when "(../operation = 'create' or " +
      "../operation = 'merge' " +
      "or ../operation = 'replace' or " +
      "../operation = 'insert')" {
      description
        "Value node only used for create, merge,
         replace, and insert operations";
    }
    description
      "Value used for this edit operation.";
  }
}

} // grouping yang-patch

grouping yang-patch-status {

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

  container yang-patch-status {
    description
      "A container representing the response message
       sent by the server after a YANG Patch edit
```

```
    request message has been processed.";

    leaf patch-id {
        type string;
        description
            "The patch-id value used in the request";
    }

    choice global-status {
        description
            "Report global errors or complete success.
            If there is no case selected then errors
            are reported in the edit-status container.";

        case global-errors {
            uses errors;
            description
                "This container will be present if global
                errors unrelated to a specific edit occurred.";
        }

        leaf ok {
            type empty;
            description
                "This leaf will be present if the request succeeded
                and there are no errors reported in the edit-status
                container.";
        }
    }

    container edit-status {
        description
            "This container will be present if there are
            edit-specific status responses to report.";

        list edit {
            key edit-id;

            description
                "Represents a list of status responses,
                corresponding to edits in the YANG Patch
                request message.  If an edit entry was
                skipped or not reached by the server,
                then this list will not contain a corresponding
                entry for that edit.";

            leaf edit-id {
                type string;
                description
```

```

        "Response status is for the edit list entry
        with this edit-id value.";
    }
    choice edit-status-choice {
        description
            "A choice between different types of status
            responses for each edit entry.";
        leaf ok {
            type empty;
            description
                "This edit entry was invoked without any
                errors detected by the server associated
                with this edit.";
        }
        leaf location {
            type inet:uri;
            description
                "Contains the Location header value that would be
                returned if this edit causes a new resource to be
                created. If the edit identified by the same edit-id
                value was successfully invoked and a new resource
                was created, then this field will be returned
                instead of 'ok'.";
        }
        case errors {
            uses errors;
            description
                "The server detected errors associated with the
                edit identified by the same edit-id value.";
        }
    }
}
}
}
}
} // grouping yang-patch-status

```

```

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 {
        config false; // needed so list error does not need a key
        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 data-resource-identifier;
    description
      "The target data resource identifier associated
       with the error, if any.";
  }
}
```

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

    container error-info {
      description
        "A container allowing additional information
         to be included in the error report.";
      // arbitrary anyxml content here
    }
  }
} // grouping errors

grouping restconf {

  description
    "A grouping that contains a YANG container
     representing the syntax and semantics of
     the RESTCONF API resource.";

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

    container config {
      description
        "Container representing the application/yang.datastore
         resource type. Represents the conceptual root of the
         unified configuration datastore containing YANG data
         nodes. The child nodes of this container are
         configuration data resources (application/yang.data)
         defined as top-level YANG data nodes from the modules
         advertised by the server in /restconf/modules.";
    }

    container operational {
      description
        "Container representing the application/yang.datastore
         resource type. Represents the conceptual root of the
         operational data supported by the server. The child
         nodes of this container are operational data resources
         (application/yang.data) defined as top-level
         YANG data nodes from the modules advertised by
```

```
        the server in /restconf/modules.";
    }

    container modules {
        description
            "Contains a list of module description entries.
            These modules are currently loaded into the server.";

        list module {
            key "name revision";
            description
                "Each entry represents one module currently
                supported by the server.";

            leaf name {
                type yang:yang-identifier;
                description "The YANG module name.";
            }
            leaf revision {
                type union {
                    type revision-identifier;
                    type string { length 0; }
                }
                description
                    "The YANG module revision date. An empty string is
                    used if no revision statement is present in the
                    YANG module.";
            }
            leaf namespace {
                type inet:uri;
                mandatory true;
                description
                    "The XML namespace identifier for this module.";
            }
            leaf-list feature {
                type yang:yang-identifier;
                description
                    "List of YANG feature names from this module that are
                    supported by the server.";
            }
            leaf-list deviation {
                type yang:yang-identifier;
                description
                    "List of YANG deviation module names used by this
                    server to modify the conformance of the module
                    associated with this entry.";
            }
        }
    }
}
```

```
}

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;
        }
    ";
}

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";
        reference
            "RFC 5277, Section 3.4, <replaySupport> element.";
    }

    leaf replay-log-creation-time {
        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.";
    }

    leaf events {
        type empty;
        description
            "Represents the entry point for establishing
            notification delivery via server sent events.";
    }
}

leaf version {
    type enumeration {
        enum "1.0" {
            description
                "Version 1.0 of the RESTCONF protocol.";
        }
    }
    config false;
    description
        "Contains the RESTCONF protocol version.";
}
} // grouping restconf

grouping notification {
    description
        "Contains the notification message wrapper definition.";

    container notification {
        description
            "RESTCONF notification message wrapper.";
    }
}
```

```
leaf event-time {
  type yang:date-and-time;
  mandatory true;
  description
    "The time the event was generated by the
     event source.";
  reference
    "RFC 5277, section 4, <eventTime> element.";
}

/* The YANG-specific notification container is encoded
 * after the 'event-time' element. The format
 * corresponds to the notificationContent element
 * in RFC 5277, section 4. For example:
 *
 * module example-one {
 *   ...
 *   notification event1 { ... }
 * }
 *
 * Encoded as element 'event1' in the namespace
 * for module 'example-one'.
 */
}
} // grouping notification
}

<CODE ENDS>
```

9. IANA Considerations

9.1. YANG Module Registry

This document registers one URI 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.
```

This document registers one YANG module in the YANG Module Names registry [[RFC6020](#)].

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

9.2. application/yang Media Type

The MIME media type for RESTCONF resources is application/yang.

Type name: application

Subtype name: yang

Required parameters: TBD

Optional parameters: TBD

Encoding considerations: TBD

Security considerations: TBD

Interoperability considerations: TBD

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

10. Security Considerations

TBD

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[XPATH] Clark, J. and S. DeRose, "XML Path Language (XPath) Version 1.0", World Wide Web Consortium Recommendation REC-xpath-19991116, November 1999, <<http://www.w3.org/TR/1999/REC-xpath-19991116>>.

Appendix A. Change Log

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

A.1. 01 to 02

- o Added Notification Model ([section 2.2](#))
- o Remove error-action from YANG Patch
- o Add "comment" and "ok" leafs to yang-patch-status container
- o Fixed YANG Patch JSON example syntax
- o Added stream resource type and streams container to /restconf container
- o Removed "vnd" from media type definitions
- o Changed yang-patch edit list from ascending uint32 key to an arbitrary string key and an ordered-by user list.
- o Several clarifications and corrections
- o Add YANG tree diagrams
- o Add application/yang.patch-status media type
- o Remove redundant "global-errors" container from "yang-patch-status" container
- o Split the /restconf/datastore entry point into 2 entry points (config and operational)
- o Remove the "config" parameter since it is no longer needed after datastore is split

A.2. 00 to 01

- o Removed incorrect /.well-known URI prefix.
- o Remove incorrect IANA request for well-known URI.
- o Clarified that API resource type nodes are defined in the ietf-restconf namespace.
- o Changed CamelCase names in example-jukebox.yang to lowercase, and updated examples.

- o Updated and corrected YANG types in ietf-restconf module.

A.3. YANG-API-01 to RESTCONF-00

- o Protocol renamed from YANG-API to RESTCONF
- o Fields are clarified. Containers and lists are sub-resources. All other YANG data node types are fields within a parent resource.
- o The 'optional-key' YANG extension has been removed.
- o The default value is returned by the server if the target resource represents a missing data node but the server is using a default value for the leaf.
- o The default for the 'depth' parameter has been changed from '1' to 'unbounded'. The depth is only limited if an integer value for this parameter is specified by the client.
- o The default for the 'format' parameter has been changed from 'json' to 'xml'.
- o expanded introduction
- o removed transactions
- o removed capabilities
- o removed usage of Range and IfRange headers
- o simplified editing model
- o removed global protocol operations from ietf-restconf.yang
- o changed RPC operation terminology to protocol operation
- o updated JSON draft reference
- o updated IANA section
- o added YANG Patch
- o added YANG definitions to ietf-restconf.yang
- o added Kent Watsen and Rex Fernando as co-authors

- o updated YANG modules so they pass pyang --ietf checking
- o changed examples so resource URIs use the module name variant to identify data resources
- o changed depth behavior so the entire server contents are not returned for "GET /restconf"; Server will stop at new resource type; e.g. yang.api --> yang.datastore returns the datastore as an empty node; yang.api --> yang.operation returns the operation name as an empty node;

Appendix B. Closed Issues

- o Which WG should do this work? NETCONF? NETMOD? It is not clear since RESTCONF builds on concepts and standards from documents owned by both working groups.

A: The NETCONF WG would do this work.

- o Should sessions be used or not? Should "reusable sessions" be used? Better for auditing? How does locking of the /restconf/config resource work for multiple edits if a session is 1 operation? When does the server release the lock and decide it has been abandoned or client was disconnected?

A: RESTCONF is a session-less protocol. It could be implemented to utilize persistent HTTP connections, but this is not required or designed into the protocol.

- o Should the "/restconf/modules" resource within the API resource be a separate resource, with its own timestamp? Currently the API timestamp is coupled to any changes to the list of loaded modules. Should the API resource be static and cacheable?

A: all child containers are considered sub-resources. The server MAY support timestamps and entity IDs for data nodes.

- o What to do about no REMOVE operation, just DELETE? The effect is local to the request; in a NETCONF edit-config it is worse, since the netconf request might create/delete/modify many nodes

A: The YANG Patch operation allows remove or delete semantics.

- o Should every YANG data node be a data resource and every YANG RPC statement an operation resource? Is a YANG extension needed to allow data modeler control of resource boundaries?

A: Nested containers and lists are considered sub-resources. Terminal nodes (leaf, leaf-list, anyxml) are considered properties of the parent resource.

- o Resource creation order and other dependencies between resources are not well identified in YANG. YANG has leafrefs and instance-identifiers, which can be used to identify some order dependencies. Are any new mechanisms needed in RESTCONF needed to identify resource creation order and other dependency requirements?

A: YANG Patch allows the client to control creation order when

multiple resources need to be edited at once. The edit operations allow the server to order all the descendant resources provided by the client, for a single datastore edit target node.

- o Encoding of leafrefs? Is there some additional meta-data needed? Do leafref nodes need to be identified in responses ([RFC 5988](#)) or is the YANG module definition sufficient to provide this meta-data?

A: no special message encoding of leaf-refs is needed. The server must understand the YANG schema no matter what protocol or encoding is used.

- o What should the default algorithm be for defining data resources? Should the default for an augment from another namespace be to start a new resource? Top-level data node defaults as a resource OK?

A: Augmented nodes do not follow different rules than other nested YANG structures. Containers and lists start new sub-resources.

Appendix C. Open Issues

C.1. message-id

- o There is no "message-id" field in a RESTCONF message. Is a message identifier needed? If so, should either the "Message-ID" or "Content-ID" header from [RFC 2392](#) be used for this purpose?

C.2. select parameter

- o What syntax should be used for the "select" query parameter? The current choices are "xpath" and "path-expr". Perhaps an additional parameter to identify the select string format is needed to allow extensibility?

C.3. server support verification

- o Are all header lines used by RESTCONF supported by common application frameworks, such as FastCGI and WSGI? If not, then should query parameters be used instead, since the QUERY_STRING is widely available to WEB applications?

C.4. error media type

- o Should the <errors> element returned in error responses be a separate media type?

C.5. additional datastores

- o How should additional datastores be supported, which may be added to the NETCONF/NETMOD framework in the future?

C.6. PATCH media type discovery

- o How does a client know which PATCH media types are supported by the server in addition to application/yang.data and application/yang.patch?

C.7. RESTCONF version

- o Is the /restconf/version field considered meta-data? Should it be returned as XRD (Extensible Resource Descriptor)? In addition or instead of the version field? Should this be the ietf-restconf YANG module revision date, instead of the string 1.0?

C.8. YANG to resource mapping

- o Since data resources can only be YANG containers or lists, what should be done about top-level YANG data nodes that are not containers or lists? Are they allowed in RESTCONF?
- o Can a choice be a resource? YANG choices are invisible to RESTCONF at this time.

C.9. .well-known usage

- o Does RESTCONF need to Use a .well-known link relation to to re-map API entry point?

The client first discovers the server's root for the RESTCONF API. In this example, it is `"/api/restconf"`:

Request

```
GET /.well-known/host-meta users 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='/api/restconf'/>
</XRD>
```

Once discovering the RESTCONF API root, the client MUST prepend it to any access to a RESTCONF resource:

Request

```
GET /api/restconf?select=version&format=json 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
```

```
{ "version": "1.0" }
```

C.10. `_self` links for HATEOAS support

- o Should there be a mode where the client can request that the resource identifier is returned in a GET request?

C.11. `netconf-state` monitoring support

- o Should long-term RESTCONF operations (i.e. SSE long-poll) be considered sessions wrt/ NETCONF monitoring "session" list? If so, what text is needed in RESTCONF draft to standardize the RESTCONF session entries?

C.12. `secure transport`

- o Details to support secure operation over TLS are needed
- o Security considerations need to be written

Appendix D. 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 song [name]
    |   |           +--rw name      string
    |   |           +--rw location  string
    |   |           +--rw format?   string
    |   |           +--rw length?   uint32
    |   +--ro artist-count?  uint32
    |   +--ro album-count?   uint32
    |   +--rw song-count?    uint32
  +--rw playlist [name]
    |   +--rw name      string
    |   +--rw description? string
    |   +--rw song [index]
    |       +--rw index  uint32
    |       +--rw id     instance-identifier
  +--rw player
    +--rw gap?   decimal64

rpcs:

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

```

D.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 "2013-10-19" {
    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";
    }
  }

  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";
```

```
        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 instance-identifier;
            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";
        }
    }
}
```

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