    Application of YANG Modeling to JSON RPCs for Interoperability Purposes
                        draft-yang-json-rpc-02

Abstract

   This document specifies the application of YANG modeling language to
   JSON RPC 2.0 for the purposes of achieving interoperability between
   implementations.

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1. **Introduction**

   A key use case for JSON encoding of data is the transfer and
   interchange of such data between applications. While some of the
   semantics desribed here will be of value for any such interchange,
   this document will concentrate on two specific use cases - Remote
   Procedure Calls (RPCs) and Notifications. There is a standard
   specification for using JSON in both - it is the JSON RPC 2.0
   specification maintained by JSON RPC working group at jsonrpc.org
   [JSONRPC20]. This specification uses JSON as described in [RFC7159]
   in messages transported over a variety of transports. For example -
   HTTP [RFC7230], 0MQ [ZEROMQ], AMQP [AMQP] etc.

   The JSON RPC 2.0 specification [JSONRPC20] has a number of well known
   shortcomings. There are no means of describing and documenting a
   particular API method. There are no means to specify how to
   interpret data received via an RPC call or notification and what data
   structures should be generated to accommodate the data. Most
   implementers have concentrated on the loss of data structure
   information as a key deficiency, while ignoring the lack of API
   description which is the actual root cause. This has led them to
   encode information about the data structures into bespoke extensions

also known as class hints and/or use of special "magic" method notations as implemented in [JABSORB], [PJ0MQ], etc. These break the core assumption of JSON being a language agnostic interchange format and result in a plethora of subtly incompatible JSON RPC implementations.

This document proposes an alternative to class hints and other non-interoperable extensions through the use of "JSON Encoding of Data Modeled with YANG" RFC [RFC7951] and YANG modeling of JSON RPCs.

2. Terminology and Notation

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in [RFC2119].

YANG is the data modeling language as described in [RFC7950], version 1.1

JSON encoding of YANG modeled data structures is described in [RFC7951]

JSON RPC 2.0 is the Remote Procedure Call and Notifications encoding as described in [JSONRPC20]

3. Modeling of JSON RPC 2.0 Interfaces in YANG

All RPCs in a particular API must be described as RPC statements in its corresponding YANG model in accordance to the rules of RFC7950 [RFC7950], section 7.14, which is expanded to cover JSON RPCs in addition to NETCONF RPCs. The RPC arguments and results must comply to subsections 7.14.2 and 7.14.3 of RFC7950 [RFC7950].

All Notifications provided by a particular API must be described as notification statements in its corresponding YANG model in accordance to the rules of RFC7950 [RFC7950], section 7.15 which is expanded to cover JSON Notifications in addition to NETCONF ones. The JSON Notification payload and substatements must comply to subsection 7.15.1 of RFC7950 [RFC7950].

While all applicable YANG statements as specified by RFC7950 [RFC7950] are supported and acceptable in both RPCs and notifications, the use of must, when, leafref and identityref is discouraged to improve interoperability with implementations which use simplistic serialization/deserialization to parse the messages and do not have a fully featured YANG interpreter. The internal mapping of an RPC name to a function call is an implementation detail outside the scope of this document. RPC method names containing

characters invalid as a part of a function name in most computing
languages are discouraged, but not prohibited.

All mappings from application data types to JSON representation types
MUST use the conventions defined in "JSON Encoding of Data Modeled
with YANG" [RFC7951]. The JSON message payload must use the I-JSON
profile according to [RFC7493].

If an application does not wish to specify the model constraints for
a particular RPC argument or Notification payload it must specify the
corresponding element as anydata in the YANG model.

JSON RPC Specification [JSONRPC20] mandates that positional arguments
are always represented as a list even if an RPC call or Notification
has a single argument.

For example, if an RPC is modelled as:

```
grouping arg-uri {
        leaf uri {
                description "A test URI.";
                mandatory true;
                type inet:uri;
        }
}
rpc test-uri {
        description "A simple example RPC.";
        input {
                uses arg-uri;
        }
}
```

Figure 1

The following payload is invalid - it violates the JSON RPC
Specification [JSONRPC20]:

```
{
        "jsonrpc": "2.0",
        "id": 3,
        "method": "test-uri",
        "params": "http://www.ietf.org"
}
```

Figure 2

The correct parameter encoding is as follows:

```
{
        "jsonrpc": "2.0",
        "id": 3,
        "method": "test-uri",
        "params": [
                "http://www.ietf.org"
        ]
}
```

                              Figure 3

or

```
{
        "jsonrpc": "2.0",
        "id": 3,
        "method": "test-uri",
        "params": {
                "uri": "http://www.ietf.org"
        }
}
```

                              Figure 4

   YANG models describing different RPCs and Notifications may be
   grouped together into a YANG module to describe an API or a set of
   APIs.

3.1. Optionality

   Omitted optional parameters for the positional form of JSON RPC 2.0
   [JSONRPC20] must be specified as null elements in the argument array.

   For example, both arguments in the test-elements RPC are optional.

```
rpc test-elements {
        description "A simple example RPC.";
        input {
                leaf element1 {
                        type string;
                }
                leaf element2 {
                        type string;
                }
        }
}
```

                              Figure 5

If only element2 is supplied, the resulting JSON RPC payload using
the positional form should be:

```
{
    "id": 3,
    "jsonrpc": "2.0",
    "method": "test-elements",
    "params": [
        null,
        "element2 value"
    ]
}
```

                              Figure 6

The named form should be:

```
{
        "jsonrpc":"2.0",
        "id":3,
        "method":"test-elements",
        "params":{
                "element2": "element2 value"
        }
}
```

                              Figure 7

While using the named form can allow an implementation to
differentiate between a parameter being supplied and a parameter
being null, implementers should not rely on this difference in
semantics as most computing language compilers and runtimes will
obscure this difference from the caller.

Trailing nulls resulting from missing parameters or an implementation
supplying a null argument MAY be stripped from a call by position
payload. The following encoding:

```
{
        "jsonrpc": "2.0",
        "id": 3,
        "method": "test-elements",
        "params": [
                "element1 value",
                null
        ]
}
```

Figure 8

can also be expressed as:

```
{
        "jsonrpc": "2.0",
        "id": 3,
        "method": "test-elements",
        "params": [
                "element1 value"
        ]
}
```

Figure 9

3.2. Default values

The receiving implementation MUST supply any default values as
specified by the model if the sender has omitted them as described in
RFC7950 [RFC7950], section 7.14.2 and 7.14.3. Thus, in a JSON RPC
the caller may omit supplying a default value. The callee (the
server) implementation is obliged to fill it in prior to passing the
data to an application. For example, for the following model:

```
rpc test-htg-2 {
        description "A simple example RPC.";
        input {
                leaf question {
                        type string;
                        default "Meaning of the Universe";
                }
        }
        output {
                leaf answer {
                        type int;
                        default 42;
                }
        }
}
```

                              Figure 10

The test-htg RPC can be invoked with the following payload:

```
{
        "jsonrpc": "2.0",
        "id": 3,
        "method": "test-htg-2",
        "params": []
}
```

                              Figure 11

The receiver implementation MUST fill the value of "Meaning of the
Universe" before passing the parsed payload to the application. The
application is not obliged to supply the answer of 42. If the
application does not supply an answer, the model aware JSON RPC2.0
implementation must add it to the payload prior to it being sent to
the caller as an RPC result.

3.3. The idl:value-type YANG Extension

This document standardizes a new YANG extension idl:value-type
compliant to [RFC7950]. This extension specifies additional metadata
necessary for a source code generator to produce the correct source
code mapping for a specific YANG type. The value provided by the
idl:value-type extension is a type hint for the generator and may
refine or override the standard type mapping rules specified in "JSON
Encoding of Data Modeled with YANG" [RFC7951]. For example:

```
idl:value-type python {
        idl:implemented-by bsct.enforce.value.TypeBoolean;
}
```

                              Figure 12

3.4. Modeling of JSON RPC 2.0 RPCs

3.4.1. Representing results

   In order to simplify integration to existing codebase, RPC calls
   returning a single result MUST emit a single value for the params key
   in the RPC message instead of a an array consisting of a one element
   for the positional form of JSON RPC 2.0 for the cases where it is
   non-ambiguous, namely lists, leaf-lists and all primitive types.

   For example, invoking the test-1 RPC in the following example

```
rpc test-1 {
        description "A simple example RPC.";
        output {
                leaf answer {
                        type int;
                }
        }
}
```

                               Figure 13

   will produce a simplified result:

```
{
    "id": 3,
    "jsonrpc": "2.0",
    "result": 42
}
```

                               Figure 14

   This simplification is ambiguous for anydata and container result
   types. If an RPC call uses the positional form to represent a
   container or anydata return value, it MUST represent it as an array
   with a single element equal to the result value.

   For example, invoking the test-2 RPC in the following example

```
rpc test-2 {
        description "A simple example RPC.";
        output {
                leaf answer {
                        type anydata;
                }
        }
}
```

Figure 15

will produce a verbose result:

```
{
    "id": 3,
    "jsonrpc": "2.0",
    "result": [
                {"key":"value"}
        ]
}
```

Figure 16

3.4.2. Modeling and expressing in JSON of data structures fully described by model

All data structures for which the model is known should be fully described in YANG as specified in [RFC7950]. The test-uri RPC in the following example is expecting a uri argument. The uri argument is fully described and modeled:

```
grouping arg-uri {
        leaf uri {
                description "A test URI.";
                mandatory true;
                type inet:uri;
        }
}
rpc test-uri {
        description "A simple example RPC.";
        input {
                uses arg-uri;
        }
        output {
                leaf passes {
                        type boolean;
                }
        }
}
```

                              Figure 17

The output is a boolean signifying if the test has passed or has
failed. For a URI value of "http://www.ietf.org", this corresponds
to the following JSON RPC request payload when using positional
arguments:

```
{
        "jsonrpc": "2.0",
        "id": 3,
        "method": "test-uri",
        "params": ["http://www.ietf.org"]
}
```

                              Figure 18

Alternatively, when using named arguments

```
{
        "jsonrpc": "2.0",
        "id": 3,
        "method": "test-uri",
        "params": {
                "uri": "http://www.ietf.org"
        }
}
```

                              Figure 19

If we assume that the remote procedure call with an argument of
"http://www.ietf.org" returns True, we will have the following
result. Positional form:

```
{
        "jsonrpc": "2.0",
        "id": 3,
        "result": true
}
```

                              Figure 20

Named form:

```
{
        "jsonrpc": "2.0",
        "id": 3,
        "result": {
                "passes": true
        }
}
```

                              Figure 21

3.4.3. Modeling and expressing in JSON of data structures with elements outside model scope

Structures which the implementer does not wish to model in YANG (from
here on referred to as "opaque") are specified as anydata. For
example the test-object RPC expects an object argument and returns an
object output. The argument and the return are opaque to the model
and may contain nested structures or structures which the implementer
has decided to keep outside the scope of the model.

```
grouping arg-object {
        leaf object {
                description "A test Object.";
                mandatory true;
                type anydata;
        }
}
rpc test-object {
        description "A simple example RPC.";
        input {
                uses arg-object;
        }
        output {
                uses arg-object;
        }
}
```

                            Figure 22

Objects opaque to the model as in this example are encoded as JSON
using the rules for anydata in [RFC7951]

For an object value of {"key":"value"}, this corresponds to the
following JSON RPC request payload when using positional arguments:

```
{
        "jsonrpc": "2.0",
        "id": 3,
        "method": "test-object",
        "params":[
                {"key": "value"}
        ]
}
```

                              Figure 23

Alternatively, when using named arguments

```
{
        "jsonrpc": "2.0",
        "id": 3,
        "method": "test-object",
        "params": {
                "object":{
                        "key": "value"
                }
        }
}
```

                              Figure 24

If we assume that the procedure call returns the following test-
object ["eeny", "meeny", "miny", "moe"], we will have the following
result. Positional form:

```
{
        "jsonrpc": "2.0",
        "id": 3,
        "result": [
                "eeny",
                "meeny",
                "miny",
                "moe"
        ]
}
```

                              Figure 25

Named form:

```
{
        "jsonrpc": "2.0",
        "id": 3,
        "result": {
                "object": [
                        "eeny",
                        "meeny",
                        "miny",
                        "moe"
                ]
        }
}
```

                              Figure 26

3.5. Modeling of JSON RPC 2.0 Notifications

3.5.1. Modeling and expressing in JSON of notifications with fully modeled data payload

All data structures for which the model is known should be fully described in YANG as specified in [RFC7950]. The testing Notification in the following example contains a uri leaf. The notification server issuing the notification is expected to supply the value and the recipients will expect the value for this leaf:

```
grouping arg-uri {
        leaf uri {
                description "A test URI.";
                mandatory true;
                type inet:uri;
        }
}
notification notify-uri {
        description "A simple notification with URI payload.";
        uses arg-uri;
}
```

Figure 27

This results in the following notification payloads. Positional arguments:

```
{
        "jsonrpc": "2.0",
        "method": "notify-uri",
        "params": [
                "http://www.ietf.org"
        ]
}
```

Figure 28

Note - there is no id member in a notification. Alternatively, when using named arguments

```
{
        "jsonrpc":"2.0",
        "method": "notify-uri",
        "params": {
                "uri": "http://www.ietf.org"
        }
}
```

Figure 29

3.5.2. Modeling and expressing in JSON of notifications with data payload outside model scope

Structures which the implementer does not wish to model in YANG and pass as object are specified as anydata. For example the notify-object notification expects an object argument as its object leaf.

```
grouping arg-object {
        leaf object {
                description "A test Object.";
                mandatory true;
                type anydata;
        }
}
notification notify-object {
        description "A simple Notification with an
                opaque object payload.";
        uses arg-object;
}
```

Figure 30

Objects opaque to the model as in this example are encoded as JSON using the rules for anydata in [RFC7951] resulting in the following example payloads for the {"key":"value"} object payload:

```
{
        "jsonrpc": "2.0",
        "method": "notify-object",
        "params": [
                {
                        "key": "value"
                }
        ]
}
```

Figure 31

Note - there is no id member in a notification. Alternatively, when
using named arguments

```
{
        "jsonrpc": "2.0",
        "method": "notify-object",
        "params": {
                "object": {
                        "key": "value"
                }
        }
}
```

                            Figure 32

3.6. Addressing Modeled Data - Yang Paths

When working with structured data in a tree form it is essential to
be able to address parts of the tree and individual elements. Yang
uses Instance Identifiers for this purpose. The current normative
reference for this is section 6.1. of [RFC7951]. It borrows the
representation from Netconf and represents IIds as an uri path.
There are issues with this encoding when used in a JSON RPC context:

o Yang IId is intended only for the purposes of addressing data. It
   does not provide semantics to address RPCs and/or Notifications
   and their argument which are the primary target of this
   specification.

o The representation in section 6.11 of [RFC7951] does not match
   JSON semantics - it uses URI syntax which requires conversion for
   each addressing operation. This approach has some advantages for
   implementations which support netconf and/or XML in parallel with
   JSON as these have existing URI parsers. It is, however, clearly
   disadvantageous for any non-netconf implementation, because it
   introduces a single "foreign" object type with a non-JSON
   serialization in the middle of a JSON specification.

The path specification specified in this draft provides a
representation of paths to address Notification and RPC objects as
well as paths into data structures. It MUST be explicitly specified
as an anydata object in any models and is not a 1:1 replacement
representation for an IId.

3.6.1. Addressing anything but an individual list element

   Containers, leaves, leaf-lists, lists as a whole (everything but an
   individual element in a list) have their Path expressed as:

```
{
        "module:top-level-container": {
                "subcontainer":{}
        }
}
```

                               Figure 33

   The path is represented as a single branch tree structure containing
   nested JSON objects. Each level key is the QName. Path terminates
   in {} to signify what is being addressed.

   Module, revision and namespace qualifiers are optional and can be
   omitted except module qualifier at top level.

3.6.2. Addressing an individual list element

   Individual list elements have their Paths expressed as:

```
{
        "module:top-level-container": {
                "list":[{
                        "key1":"value1",
                        "key2":"value2"
                }]
        }
}
```

                               Figure 34

   Path is represented as a single branch tree structure containing
   nested JSON objects up to the list level.

   At list level the QName is followed by [] to signify a list. The
   list contains a single object with key-value pairs uniquely
   identifying the list element.

3.6.3. Addressing inside an individual list element

   Individual list elements have their Paths expressed as:

```
{
        "module:top-level-container": {
               "list":[{
                       "key1":"value1",
                       "key2":"value2",
                       "list-element": {}
               }]
        }
}
```

                               Figure 35

   This form is obtained by adding a path as described in Section 3.6.1
   section to the list element IId representation described in
   Section 3.6.2.

4. Normative References

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