



RELEASE CANDIDATE

## **OCPP 2.0.1**

### **Part 4 - JSON over WebSockets implementation guide**

December 2019

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# Disclaimer

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# 1. Introduction

## 1.1. Purpose of this document

The purpose of this document is to give the reader the information required to create a correct interoperable OCPP [JSON](#) implementation (OCPP-J). We will try to explain what is mandatory, what is considered good practice and what one should not do, based on our own experience. Undoubtedly misunderstandings or ambiguities will remain but by means of this document we aim to prevent them as much as possible.

## 1.2. Intended audience

This document is intended for developers looking to understand and/or implement OCPP JSON in a correct and interoperable way. Rudimentary knowledge of implementing web services on a server or embedded device is assumed.

## 1.3. OCPP-S and OCPP-J

With the introduction of OCPP 1.6, there were two different flavors of OCPP; SOAP and JSON. To avoid confusion in communication on the type of implementation we recommend using the distinct suffixes -J and -S to indicate JSON or SOAP. In generic terms this would be OCPP-J for JSON and OCPP-S for SOAP. Version specific terminology would be OCPP1.6J or OCPP1.2S. If no suffix is specified for OCPP 1.2 or 1.5 then a SOAP implementation must be assumed. As of release 1.6 this can no longer be implicit and should always be made clear. If a system supports both the JSON and SOAP variant it is considered good practice to label this OCPP1.6JS instead of just OCPP1.6.

OCPP 2.0.1 only supports JSON, but it is preferable to keep using the -J designation. As a new transport mechanism might be introduced in a future version of OCPP. So it will be OCPP2.0.1J.

## 1.4. Conventions

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 [\[RFC2119\]](#).

## 1.5. Definitions & Abbreviations

Abbreviation	Description
IANA	Internet Assigned Numbers Authority ( <a href="http://www.iana.org">www.iana.org</a> ).
OCPP-J	OCPP communication over WebSocket using JSON. Specific OCPP versions should be indicated with the J extension. OCPP2.0.1J means we are talking about a JSON/WebSocket implementation of 2.0.1.
OCPP-S	OCPP communication over SOAP and HTTP(S). As of version 1.6 this should explicitly mentioned. Older versions are assumed to be S unless clearly specified otherwise, e.g. OCPP1.5 is the same as OCPP1.5S
RPC	Remote procedure call
WAMP	WAMP is an open WebSocket subprotocol that provides messaging patterns to handle asynchronous data.

## 1.6. References

Reference	Description
[EMI3-BO]	"eMI3 standard version V1.0" <a href="http://emi3group.com/documents-links/">http://emi3group.com/documents-links/</a>
[OCPP2.0-PART2]	"OCPP 2.0.1: Part 2 - Specification". <a href="http://www.openchargealliance.org/downloads/">http://www.openchargealliance.org/downloads/</a>
[RFC1951]	"DEFLATE Compressed Data Format Specification version 1.3". <a href="https://www.ietf.org/rfc/rfc1951">https://www.ietf.org/rfc/rfc1951</a>
[RFC2119]	"Key words for use in RFCs to Indicate Requirement Levels". S. Bradner. March 1997. <a href="http://www.ietf.org/rfc/rfc2119.txt">http://www.ietf.org/rfc/rfc2119.txt</a>
[RFC2616]	"Hypertext Transfer Protocol – HTTP/1.1". <a href="http://tools.ietf.org/html/rfc2616">http://tools.ietf.org/html/rfc2616</a>
[RFC2617]	"HTTP Authentication: Basic and Digest Access Authentication". <a href="http://tools.ietf.org/html/rfc2617">http://tools.ietf.org/html/rfc2617</a>
[RFC3629]	"UTF-8, a transformation format of ISO 10646". <a href="http://tools.ietf.org/html/rfc3629">http://tools.ietf.org/html/rfc3629</a>
[RFC3986]	"Uniform Resource Identifier (URI): Generic Syntax". <a href="http://tools.ietf.org/html/rfc3986">http://tools.ietf.org/html/rfc3986</a>
[RFC5246]	"The Transport Layer Security (TLS) Protocol; Version 1.2". <a href="http://tools.ietf.org/html/rfc5246">http://tools.ietf.org/html/rfc5246</a>
[RFC6455]	"The WebSocket Protocol". <a href="http://tools.ietf.org/html/rfc6455">http://tools.ietf.org/html/rfc6455</a>
[RFC7515]	"JSON Web Signatures (JWS)". <a href="https://tools.ietf.org/html/rfc7515">https://tools.ietf.org/html/rfc7515</a>
[RFC7518]	"JSON Web Algorithms (JWA)". <a href="https://tools.ietf.org/html/rfc7518">https://tools.ietf.org/html/rfc7518</a>
[RFC7692]	"Compression Extensions for WebSocket". <a href="https://tools.ietf.org/html/rfc7692">https://tools.ietf.org/html/rfc7692</a>
[RFC8259]	"The JavaScript Object Notation (JSON) Data Interchange Format". T. Bray. December 2017. <a href="https://tools.ietf.org/html/rfc8259">https://tools.ietf.org/html/rfc8259</a>
[WAMP]	<a href="http://wamp.ws/">http://wamp.ws/</a>

## 2. Benefits & Issues

The WebSocket protocol is defined in [RFC6455]. Working implementations of earlier draft WebSocket specifications exist, but OCPP-J implementations SHOULD use the protocol described in [RFC6455].

Be aware that WebSocket defines its own message structure on top of TCP. Data sent over a WebSocket, on a TCP level, is wrapped in a WebSocket frame with a header. When using a framework this is completely transparent. When working for an embedded system however, WebSocket libraries may not be available and then one has to frame messages correctly according to [RFC6455] him/herself.

## 3. WebSockets

For the connection between a Charging Station and a Charging Station Management System (CSMS) using OCPP-J, the CSMS acts as a WebSocket server and the Charging Station acts as a WebSocket client.

### 3.1. Client request

To set up a connection, the Charging Station initiates a WebSocket connection as described in [\[RFC6455\]](#) section 4, "Opening Handshake".

OCPP-J imposes extra constraints on the URL and the WebSocket subprotocol, detailed in the following two sections 4.1.1 and 4.1.2.

The Client (Charging Station) SHALL keep this WebSocket connection open all the time.

#### 3.1.1. The connection URL

To initiate a WebSocket connection, the Charging Station needs a URL ([\[RFC3986\]](#)) to connect to. This URL is henceforth called the "connection URL". This connection URL is specific to a Charging Station. The Charging Station's connection URL contains the Charging Station identity so that the CSMS knows which Charging Station a WebSocket connection belongs to. However it is RECOMMENDED to let the CSMS NOT solely rely on the connection URL to identify a Charging Station, but to double-check the Charging Station's identity against their authentication credentials.

A CSMS supporting OCPP-J MUST provide at least one OCPP-J endpoint URL, from which the Charging Station SHOULD derive its connection URL. This OCPP-J endpoint URL can be any URL with a "ws" or "wss" scheme. How the Charging Station obtains an OCPP-J endpoint URL is outside of the scope of this document.

To derive its connection URL, the Charging Station modifies the OCPP-J endpoint URL by appending to the path first a '/' (U+002F SOLIDUS) and then a string uniquely identifying the Charging Station. This uniquely identifying string has to be percent-encoded as necessary as described in [\[RFC3986\]](#).

Example 1: for a Charging Station with identity "CS001" connecting to a CSMS with OCPP-J endpoint URL "ws://csms.example.com/ocpp" this would give the following connection URL:

`ws://csms.example.com/ocpp/CS001`

Example 2: for a Charging Station with identity "RDAM 123" connecting to a CSMS with OCPP-J endpoint URL "wss://csms.example.com/ocppj" this would give the following URL:

`wss://csms.example.com/ocppj/RDAM%20123`

The Charging Station identity datatype is *identifierString* (For definition see [\[OCPP2.0.1-PART2\]](#) The maximum length of the Charging Station identity is: 48 (Note: Maximum length was chosen to ensure compatibility with EVSE ID from [\[EMI3\]](#) "Part 2: business objects."

#### 3.1.2. OCPP version

The OCPP version(s) MUST be specified in the Sec-WebSocket-Protocol field. This SHOULD be one or more of the following values:

Table 1. OCPP Versions

OCPP version	WebSocket subprotocol name
1.2	ocpp1.2
1.5	ocpp1.5
1.6	ocpp1.6
2.0	ocpp2.0
2.0.1	ocpp2.0.1

The ones for OCPP 1.2, 1.5, 1.6, 2.0 and 2.0.1 are official WebSocket subprotocol name values. They are registered as such with IANA.

Note that OCPP 1.2 and 1.5 are in the list. Since the JSON over WebSocket solution is independent of the actual message content the solution can be used for older OCPP versions as well. Please keep in mind that in these cases the implementation should preferably also maintain support for the SOAP based solution to be interoperable.

It is considered good practice to include the OCPP version as part of the OCPP-J endpoint URL string. If you run a web service that can handle multiple protocol versions on the same OCPP-J endpoint URL this is not necessary of course.

### 3.1.3. Example of an opening HTTP request

The following is an example of an opening HTTP request of an OCPP-J connection handshake:

```
GET /webServices/ocpp/CS3211 HTTP/1.1  
  
Host: some.server.com:33033  
  
Upgrade: websocket  
  
Connection: Upgrade  
  
Sec-WebSocket-Key: x3JJHmbDL1EzLkh9GBhXDw==  
  
Sec-WebSocket-Protocol: ocpp2.0.1, ocpp1.6  
  
Sec-WebSocket-Version: 13
```

The bold parts are found as such in every WebSocket handshake request, the other parts are specific to this example.

In this example, the CSMS's OCPP-J endpoint URL is "ws://some.server.com:33033/webServices/ocpp". The Charging Station's unique identifier is "CS3211", so the path to request becomes "webServices/ocpp/CS3211".

With the Sec-WebSocket-Protocol header, the Charging Station indicates here that it can use OCPP2.0.1J and OCPP1.6J, with a preference for the former.

The other headers in this example are part of the HTTP and WebSocket protocols and are not relevant to those implementing OCPP-J on top of third-party WebSocket libraries. The roles of these headers are explained in [\[RFC2616\]](#) and [\[RFC6455\]](#).

## 3.2. Server response

Upon receiving the Charging Station's request, the CSMS has to finish the handshake with a response as described in [\[RFC6455\]](#).

The following OCPP-J-specific conditions apply:

- If the CSMS does not recognize the Charging Station identifier in the URL path, it SHOULD send an HTTP response with status 404 and abort the WebSocket connection as described in [\[RFC6455\]](#).
- If the CSMS does not agree to using one of the subprotocols offered by the client, it MUST complete the WebSocket handshake with a response without a Sec-WebSocket-Protocol header and then immediately close the WebSocket connection.

So if the CSMS accepts the above example request and agrees to using OCPP 2.0.1J with the Charging Station, the CSMS's response will look as follows:

```
HTTP/1.1 101 Switching Protocols  
  
Upgrade: websocket  
  
Connection: Upgrade  
  
Sec-WebSocket-Accept: s3pPLMBiTxaQ9kYGzzhZRbK+xOo=  
  
Sec-WebSocket-Protocol: ocpp2.0.1
```

The bold parts are found as such in every WebSocket handshake response, the other parts are specific to this example.

The role of the Sec-WebSocket-Accept header is explained in [\[RFC6455\]](#).

The Sec-WebSocket-Protocol header indicates that the server will be using OCPP2.0.1J on this connection.

For a definition on how a server SHALL report a 'failure to process the message', see: [CALLERROR](#)

## 3.3. WebSocket Compression

OCPP 2.0.1 supports RFC 7692: Compression Extensions for WebSocket see: [\[RFC6455\]](#)

Table 2. WebSocket compression support requirement for devices

Device	WebSocket Compression Support
Charging Station	Optional
CSMS	Required
Local Controller	Required

OCPP Requires the CSMS (and Local Controller) to support [RFC 7692](#), WebSocket compression is seen as a relative simple way to reduce mobile data usage. For a Charging Station this is not a hard requirement, as this might be more complex to implement on an embedded platform, but as this is seen as efficient solution to reduce mobile data usage, it is RECOMMENDED to be implemented on a Charging Station that uses a mobile data connection.

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[RFC 7692](#) allows the Charging Station and the CSMS to do a negotiation during the connection setup. When both parties support the Compression Extension they will then use DEFLATE compression ([\[RFC1951\]](#)) when sending data over the line. When one of the parties doesn't support it, the JSON will be sent uncompressed (like in OCPP 1.6J).

When the Charging Station detects that compression is not used, it is RECOMMENDED not to close the connection, as turning of compression can be very useful during development, testing and debugging.

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For more detailed information read the [RFC 7692](#).

## 4. RPC framework

### 4.1. Introduction

A websocket is a full-duplex connection, simply put a pipe where data goes in and data can come out and without a clear relation between in and out. The WebSocket protocol by itself provides no way to relate messages as requests and responses. To encode these request/response relations we need a small protocol on top of WebSocket. This problem occurs in more use cases of WebSocket so there are existing schemes to solve it. The most widely-used is WAMP (see [\[WAMP\]](#)) but with the current version of that framework handling RPCs symmetrically is not WAMP compliant. Since the required framework is very simple we decided to define our own framework, inspired by WAMP, leaving out what we do not need and adding what we find missing.

Basically what we need is very simple: we need to send a message (CALL) and receive a reply ([CALLRESULT](#)) or an explanation why the message could not be handled properly ([CALLERROR](#)). For possible future compatibility we will keep the numbering of these message in sync with WAMP. Our actual OCPP message will be put into a wrapper that at least contains the type of message, a unique message ID and the payload, the OCPP message itself.

#### 4.1.1. Synchronicity

A Charging Station or CSMS SHALL NOT send a CALL message to the other party unless all the CALL messages it sent before have been responded to or have timed out. This does not mean that the CSMS cannot send a message to another Charging Station, while waiting for a response of a first Charging Station, this rule is per OCPP-J connection. A CALL message has been responded to when a [CALLERROR](#) or [CALLRESULT](#) message has been received with the message ID of the CALL message.

A CALL message has timed out when:

- it has not been responded to, and



- 
- an implementation-dependent timeout interval has elapsed since the message was sent.

Implementations are free to choose this timeout interval. It is RECOMMENDED that they take into account the kind of network used to communicate with the other party. Mobile networks typically have much longer worst-case round-trip times than fixed lines.

**NOTE**

The above requirements do not rule out that a Charging Station or CSMS will receive a CALL message from the other party while it is waiting for a [CALLERROR](#) or [CALLRESULT](#). Such a situation is difficult to prevent because CALL messages from both sides can always cross each other.

## 4.1.2. Message validity and Character encoding

The whole message consisting of wrapper and payload MUST be valid JSON encoded with the UTF-8 (see [RFC3629](#)) character encoding. Furthermore, the Charging Station and CSMS have the right to reject messages which are not conform the JSON schemas.

Note that all valid US-ASCII text is also valid UTF-8, so if a system sends only US-ASCII text, all messages it sends comply with the UTF-8 requirement. Non US-ASCII characters SHOULD only be used for sending natural-language text. An example of such natural-language text is the MessageType which contains the text of a DisplayMessage in OCPP 2.0.1

## 4.1.3. The message type

To identify the type of message one of the following Message Type Numbers MUST be used.

Table 3. Message types

MessageType	Message Type Number	Description
CALL	2	Request message
CALLRESULT	3	Response message
CALLERROR	4	Error response to a request message

When a server receives a message with a Message Type Number not in this list, it SHALL ignore the message payload. Each message type may have additional required fields.

## 4.1.4. The message ID

The message ID serves to identify a request. A message ID for any CALL message MUST be different from all message IDs previously used by the same sender for any other CALL messages on the same WebSocket connection. A message ID for a CALLRESULT or CALLERROR message MUST be equal to that of the CALL message that the CALLRESULT or CALLERROR message is a response to.

Table 4. Unique Message ID

Name	Datatype	Restrictions
messageld	string[36]	Unique message ID, maximum length of 36 characters, to allow for UUIDs/GUIDs

## 4.1.5. JSON Payload

The Payload of a message is a JSON object containing the arguments relevant to the Action.

If there is no payload JSON allows for two different notations: *null* or an empty object *{}*. Although it seems trivial, we consider it good practice to only use the empty object statement. Null usually represents something undefined, which is not the same as empty, and also *{}* is shorter.

When a field is optional in the OCPP action (0..1 or 0..\*) and is left empty for a specific request/response, JSON allows for a couple of different ways to put this in a JSON string. But because OCPP is designed for wireless links, OCPP only allows 1 option: Do not put the field in the payload (so null, {} or [] are not allowed for an empty field).

When a field has a cardinality of zero/one to many (0..\* or 1..\*) and it has been given one entity, then it will still remain a list, but of size 1.

## 4.1.6. Action

The Action field in the CALL message MUST be the OCPP message name without the "Request" suffix.

For example: For a "BootNotificationRequest" the action field will be set to "BootNotification".

BTW: The CALLRESULT does not contain the action field. A client can match the Response (CALLRESULT) with the Request (CALL) via the Messageld field.

## 4.1.7. Message Validity

An message is only valid when:

- [Action](#) is a known [Action](#).
- The JSON payload is valid JSON
- All the required field for the [Action](#) are present
- All data is of the correct data type.

When a message is not valid, the server SHALL respond with a [CALLERROR](#)

## 4.2. Message structures for different message types

### NOTE

You may find the Charging Station identity missing in the following paragraphs. The identity is exchanged during the WebSocket connection handshake and is a property of the connection. Every message is sent by or directed at this identity. There is therefore no need to repeat it in each message.

### 4.2.1. CALL

A CALL always consists of 4 elements: The standard elements MessageTypeId and MessageId, a specific Action that is required on the other side and a payload, the arguments to the Action. The syntax of a CALL looks like this:

[<MessageTypeId>, "<MessageId>", "<Action>", {<Payload>}]

Table 5. CALL Fields

Field	Datatype	Meaning
MessageTypeId	integer	This is a Message Type Number which is used to identify the type of the message.
MessageId	string[36]	This is a unique identifier that will be used to match request and result.
Action	string	The name of the remote procedure or action. This field SHALL contain a case-sensitive string. The field SHALL contain the OCPP Message name without the "Request" suffix. For example: For a "BootNotificationRequest", this field shall be set to "BootNotification".
Payload	JSON	JSON Payload of the action, see: <a href="#">JSON Payload</a> for more information.

For example, a BootNotificationRequest could look like this:

```
[2,
  "19223201",
  "BootNotification",
  {
    "reason": "PowerUp",
    "chargingStation": {
      "model": "SingleSocketCharger",
      "vendorName": "VendorX"
    }
  }
]
```

### 4.2.2. CALLRESULT

If the call can be handled correctly the result will be a regular CALLRESULT. Error situations that are covered by the definition of the OCPP response definition are not considered errors in this context. They are regular results and as such will be treated as a normal CALLRESULT, even if the result is undesirable for the recipient.

A CALLRESULT always consists of 3 elements: The standard elements MessageTypeId and MessageId and a payload, containing the response to the Action in the original Call.

The syntax of a CALLRESULT looks like this:

[<MessageTypeId>, "<MessageId>", {<Payload>}]

Table 6. CALLRESULT Fields

Field	Datatype	Meaning
MessageTypeId	integer	This is a Message Type Number which is used to identify the type of the message.
MessageId	string[36]	This must be the exact same ID that is in the call request so that the recipient can match request and result.
Payload	JSON	JSON Payload of the action, see: <a href="#">JSON Payload</a> for more information.

For example, a BootNotification response could look like this:

```
[ 3,
  "19223201",
  {
    "currentTime": "2013-02-01T20:53:32.486Z",
    "interval": 300,
    "status": "Accepted"
  }
]
```

### 4.2.3. CALLERROR

We only use CALLERROR in two situations:

1. An error occurred during the transport of the message. This can be a network issue, an availability of service issue, etc.
2. The call is received but the content of the call does not meet the requirements for a proper message. This could be missing mandatory fields, an existing call with the same unique identifier is being handled already, unique identifier too long, invalid JSON or OCPP syntax etc.

When a server needs to report a 'failure to process the message', the server SHALL use a Message Type: CallError (MessageTypeNumber = 4).

When a server receives a corrupt message, the CALLERROR SHALL NOT directly include syntactically invalid JSON (For example, without encoding it first). When also the MessageId cannot be read, the CALLERROR SHALL contain "-1" as MessageId.

When a message contains any invalid OCPP and/or it is not conform the JSON schema, the system is allowed to drop the message.

A CALLERROR always consists of 5 elements: The standard elements MessageTypeId and MessageId, an errorCode string, an errorDescription string and an errorDetails object.

The syntax of a CALLERROR looks like this:

```
[<MessageType>, "<MessageId>", "<errorCode>", "<errorDescription>", {<errorDetails>}]
```

Table 7. CALLERROR Fields

Field	Datatype	Meaning
MessageTypeId	integer	This is a Message Type Number which is used to identify the type of the message.
MessageId	string[36]	This must be the exact same id that is in the call request so that the recipient can match request and result.
ErrorCode	string	This field must contain a string from the <a href="#">RPC Framework Error Codes table</a> .
ErrorDescription	string[255]	Should be filled in if possible, otherwise a clear empty string "".
ErrorDetails	JSON	This JSON object describes error details in an undefined way. If there are no error details you MUST fill in an empty object {}.

For example, a CALLERROR could look like this:

```
[4,
  "162376037",
  "NotSupported",
  "SetDisplayMessageRequest not implemented",
  {}
]
```

## 4.3. RPC Framework Error Codes

The following table contains all the allowed error codes for the OCPP RPC Framework.

Table 8. Valid Error Codes

ErrorCode	Description
FormatViolation	Payload for Action is syntactically incorrect
GenericError	Any other error not covered by the more specific error codes in this table
InternalError	An internal error occurred and the receiver was not able to process the requested Action successfully
MessageTypeNotSupported	A message with an Message Type Number received that is not supported by this implementation.
NotImplemented	Requested Action is not known by receiver
NotSupported	Requested Action is recognized but not supported by the receiver
OccurrenceConstraintViolation	Payload for Action is syntactically correct but at least one of the fields violates occurrence constraints
PropertyConstraintViolation	Payload is syntactically correct but at least one field contains an invalid value
ProtocolError	Payload for Action is not conform the PDU structure
RpcFrameworkError	Content of the call is not a valid RPC Request, for example: MessageId could not be read.
SecurityError	During the processing of Action a security issue occurred preventing receiver from completing the Action successfully
TypeConstraintViolation	Payload for Action is syntactically correct but at least one of the fields violates data type constraints (e.g. "somestring": 12)

## 4.4. Extension fallback mechanism

Future versions of OCPP might add extra Message Types (other than [CALL](#), [CALLRESULT](#) and [CALLERROR](#))

When an OCPP 2.0.1 implementation receives a message with an unknown message type, it SHALL respond with an [CALLERROR](#) with errorCode: [MessageTypeNotSupported](#). This SHOULD notify the sending party about the not supported Message Type. The Sending Party SHALL then either terminate the connection, or fallback to the known: [CALL](#), [CALLRESULT](#) and [CALLERROR](#).

# 5. Connection

## 5.1. Data integrity

For data integrity we rely on the underlying TCP/IP transport layer mechanisms.

## 5.2. WebSocket Ping in relation to OCPP Heartbeat

The WebSocket specification defines Ping and Pong frames that are used to check if the remote endpoint is still responsive. In practice this mechanism is also used to prevent the network operator from quietly closing the underlying network connection after a certain period of inactivity. This websocket feature can be used as a substitute for most of the OCPP Heartbeat messages, but cannot replace all of its functionality.

An important aspect of the Heartbeat response is time synchronisation. The Ping and Pong frames cannot be used for this so at least one original Heartbeat message a day is recommended to ensure a correct clock setting on the Charging Station.

## 5.3. Reconnecting

When the connection is lost, the Charging Station SHALL try to reconnect. When reconnecting, the Charging Station SHALL use an increasing back-off time with some randomization until it has successfully reconnected. This prevents an overload of the CSMS when all Charging Stations reconnect after a restart of the CSMS.

The first reconnection attempts SHALL be after a back-off time of: `RetryBackOffWaitMinimum` seconds, plus a random value with a maximum of `RetryBackOffRandomRange` seconds. After every failed reconnection attempt the Charging Station SHALL double the previous back-off time, with a maximum of `RetryBackOffRepeatTimes`, adding a new random value with a maximum of `RetryBackOffRandomRange` seconds to every reconnection attempt. After `RetryBackOffRepeatTimes` reconnection attempts, the Charging Station SHALL keep reconnecting with the last back-off time, not increasing it any further.

When reconnecting, a Charging Station should not send a `BootNotification` unless one or more of the elements in the `BootNotification` have changed since the last connection. For the previous SOAP based solutions this was considered good practice but when using WebSocket the server can already make the match between the identity and a communication channel at the moment the connection is established. There is no need for an additional message.

## 5.4. Network node hierarchy

The physical network topology is not influenced by a choice for JSON or SOAP. In case of JSON however the issues with Network Address Translation (NAT) have been resolved by letting the Charging Station open a TCP connection to the CSMS and keeping this connection open for communication initiated by the CSMS. It is therefore no longer necessary to have a smart device capable of interpreting and redirecting SOAP calls in between the CSMS and the Charging Station.

## 6. OCPP Routing

For some topologies it is required to route OCPP-J messages. For example when implementing a Local Controller.

This section contains a solution for OCPP message routing that will work with any Charging Station and CSMS.

### 6.1. Local Controller

A Local controller is a device that sits between the CSMS and any number of Charging Stations, creating a local group. It is located near to the Charging Station (maybe even connected wired to the Charging Stations), so it does not have problem of losing the connection to the Charging Stations. This is practically useful for doing Local Smart Charging: load balancing between the Charging Stations on the same location. The Local Controller can see all the messages, ongoing transactions etc. It can send charging profiles to the Charging Station to influence the energy used by the Charging Stations, this way preventing the group to use more energy than available at the location at that time.

The Local Controller SHALL work so the Charging Station doesn't have to behave different when connected to the Local Controller, compared to a direct connection to a CSMS. A Local Controller SHALL work so that a Charging Station can work out of the box with the Local Controller, requiring only the parameters that are needed to connect to the Local Controller to be set. The Local Controller SHALL work so that the CSMS can not notice if the Charging Station is connecting to it directly, or via the Local Controller.

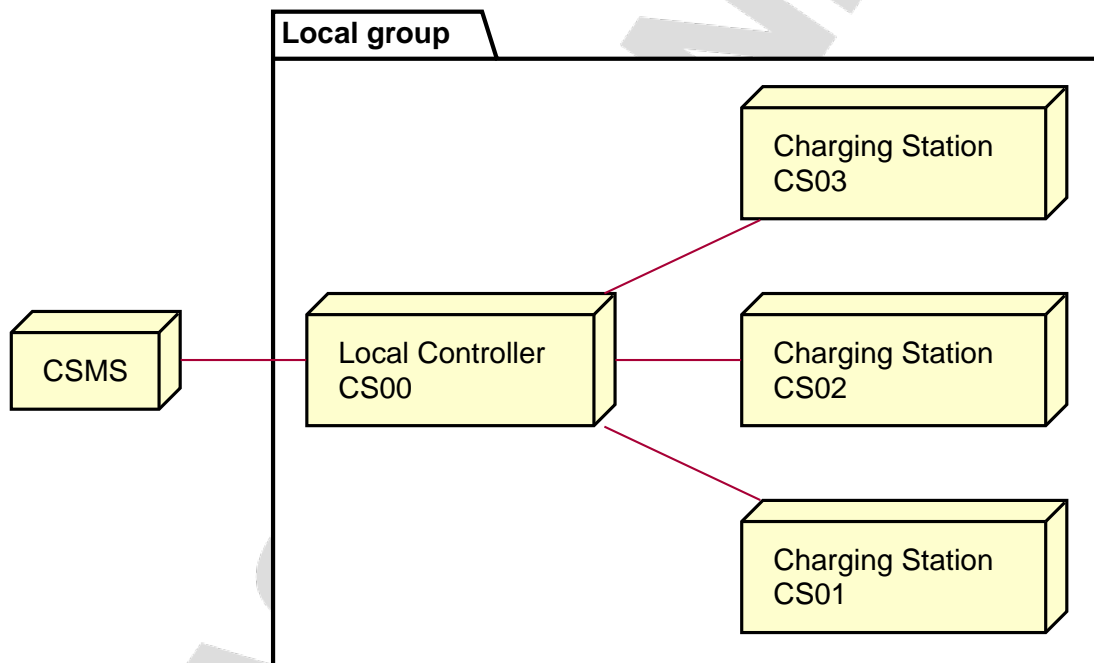


Figure 1. Local Controller Topology

### 6.2. Connections

For each Charging Station that connects to the Local Controller, two connections will be established:

1. A WebSocket connection from the Charging Station to the Local Controller (configured in the Charging Station)
2. A WebSocket connection from the Local Controller to the CSMS (configured in the Local Controller)

Both connections should use a similar connection URI with the same Charging Station identifier. To the CSMS, the connection from the Local Controller appears to be a regular Charging Station connection.

The Local Controller may open a separate WebSocket connection to the CSMS that allows the CSMS to address the Local Controller directly, which may be useful for changing settings or setting overall Charging Profiles.

When a Charging Station connects to the Local Controller, it SHALL connect to it like it would to a CSMS, using the same URI Path in the [connection URL](#) as it would use to connect to the CSMS. When the connection between Charging Station and the CSMS is successfully set up, the Local Controller SHALL set up a WebSocket connection to the CSMS with the same URI Path in the [connection URL](#) that was used by the Charging Station to setup the connection. The Local Controller SHALL open a WebSocket connection for every Charging Station that connects to it.



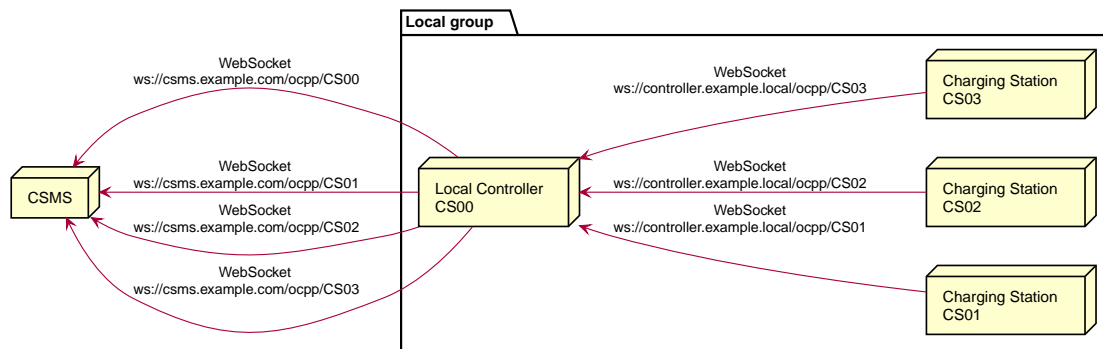


Figure 2. Local Controller WebSocket Connections

## 6.3. Connection loss

Whenever one or more WebSocket connections between CSMS and the Local Controller are lost, the Local Controller SHALL close all corresponding WebSockets to the Charging Stations that are connected to it. This is needed to force the Charging Station to queue messages as it would have done if it would have been connected to the CSMS directly and would have lost the connection to that CSMS.

Whenever the connection between a Charging Station and the Local Controller is lost, the Local Controller SHALL close the WebSocket connection it has for the Charging Station to the CSMS. This is needed to let the CSMS know the Charging Station is offline and no CSMS initiated messages can be sent to it.

## 6.4. Local Controller initiated messages

The Local Controller SHALL relay any Charging Station initiated message to the CSMS (and vice versa).

Since the Local Controller can also initiate its own messages to the Charging Station(s), a Local Controller SHALL take care of the following:

1. If a Local Controller sends its own messages to a Charging Station, it SHALL guarantee that its messages have IDs that do not collide with IDs used by the CSMS, now and in the future. This can be done by either assigning a range of numbers to the Local Controller to use (and the CSMS to skip), or by using UUIDs/GUIDs.
2. Replies to messages from the Charging Station to messages initiated by the Local Controller SHALL NOT be sent to the CSMS.

## 6.5. Local Controller Security

For the local controller, the normal OCPP security mechanisms will be used, as described in [\[OCPP2.0.1-PART2\]](#), part A. Security. All security profiles described there MAY be used when a Local Controller is deployed. The security section (part A) only describes the roles of the CSMS, and Charging Station. When a local controller is used, the security specification SHALL be interpreted as follows:

- In the connection from the Charging Station to the Local Controller, the Charging Station SHALL act as the Charging Station, and the Local Controller SHALL act as the CSMS. When TLS is used, the Local Controller SHALL be the TLS server, and the Charging Station SHALL be the TLS client.
- In the connection from the Local Controller to the CSMS, the Local Controller SHALL act as the Charging Station, and the CSMS SHALL act as the CSMS. When TLS is used, the CSMS SHALL be the TLS server, and the Local Controller SHALL be the TLS client.

When TLS with Client Side Certificates is used, the Local Controller SHALL have both a CSMS Certificate, and a Charging Station certificate (see [\[OCPP2.0.1-PART2\]](#) Part A - Keys used in OCPP), as it can function in both roles. These certificates SHALL be unique to the Local Controller. The Local Controller SHALL NOT store the Charging Station certificates of the attached Charging Stations. It SHALL also NOT store the CSMS Certificate of the CSMS. These certificates SHALL be kept private on their respective owners. The Local Controller SHALL only use its own certificates for setting up the TLS connections.

It SHALL be possible to distinguish the Local Controller from the CSMS based on the URL in the CSMS Certificate. Because the Local Controller is placed in the field, there is a risk that its certificates get stolen from it, e.g. by an attack on the hardware. In that case, it SHALL only be possible to use the CSMS Certificate on the Local Controller to communicate with the attached Charging Stations, not with any other Charging Stations in the infrastructure.

The TLS connections terminate on the Local Controller. So, the Local Controller can both read and manipulate data sent between

the CSMSs and Charging Stations. If the security of the Local Controller is compromised, it will affect all attached Charging Stations. It is therefore RECOMMENDED to take sufficient security measures to protect the Local Controller. It is also RECOMMENDED to sign critical commands or replies with the mechanism described in [Signed Messages](#). In this way, it can be detected if the Local Controller tries to manipulate data.

## 7. Signed Messages

For certain architectures it can be useful to use signed OCPP messages. This gives the Charging Station and the CSMS the ability to guarantee that messages are sent by the other party. For example when a Local Controller is involved, the Charging Station can know that a message received from the Local Controller is created and signed by the CSMS.

Message signing can also be used when forwarding data from the Charging Station or the CSMS to 3th parties such as a DSO (Distribution System Operator).

Because message signing is not needed in all architectures and scenarios, it is not required for all OCPP implementations. It will depend on the security requirements if this is required.

This section defines a method to digitally sign any OCPP-J message. For each normal OCPP message an equivalent signed message is defined that encapsulates the normal message, and adds a digital signature.

### 7.1. Signed Message Format

For Signed OCPP Messages, JWS is used. For more information see: [\[RFC7515\]](#).

Suppose we have an OPC calls encoded in the OCPP-J message:

```
[<MessageType>, "<MessageId>", {<Extension>}, "<Action>", {<Payload>}]
```

Then we define the equivalent signed message as follows.

```
[<MessageType>, "<MessageId>", {<Extension>}, "<SignedAction>", {<SignedPayload>}]
```

The MessageType and MessageId SHALL stay the same. The <SignedAction> field SHALL be the action name (<Action>) with the string "-Signed" appended. For instance, if "<Action>" is "BootNotification", then "<SignedAction>" is "BootNotification-Signed". The <SignedPayload> SHALL be the JWS encoding of the payload, computed according to the following settings:

- The JWS Payload SHALL be the <Payload> from the original message.
- The JWS Protected Header SHALL contain a field called "OCPPAction" containing the name (<Action>) of the OCPP action, and a field called "OCPPMessageType" containing the message ID (<MessageType>).
- The JWS Protected Header SHOULD contain the x5t#S256 field to identify the key used for signing, as specified in Section 7.4.
- The <SignedPayload> SHALL be encoded using the Flattened JWS JSON Serialization syntax.

### 7.2. Handling Signed Messages

When a Charging Station or CSMS receives a signed message, it SHALL extract the encapsulated normal message. It SHALL process it normally, following the OCPP 2.0.1 standard. It MAY perform additional actions that use the digital signature. This is optional, because a secure connection between the CSMS and the Charging Station is expected, hence a second process to validate a signature on message level is redundant. When a Charging Station receives a signed request, and it supports digital signing, it SHALL send a signed reply.

### 7.3. Allowed Algorithms

The algorithms allowed for use with JSON Web Signatures are defined in the JSON Web Algorithms standard [\[RFC7518\]](#). To limit the cryptographic algorithms that a Charging Station has to implement, for OCPP the same algorithms SHALL be used as for the TLS connection used to secure communications. This means that for generating the digital signatures, the Charging Station and CSMS SHALL use the following algorithms from the JSON Web Algorithms standard [\[RFC7518\]](#), section 3.1:

- ES256: ECDSA using P-256 and SHA-256
- RS256: RSASSA-PKCS1-v1\_5 using SHA-256
- RS384: RSASSA-PKCS1-v1\_5 using SHA-384

Note that RS256 and ES256 are the algorithms recommended by [\[RFC7518\]](#).

## 7.4. Key Management

This section does not prescribe specific keys to be used for digital signatures. The CSMS Certificate and Charging Station Certificate, used for setting up a secure TLS connection, MAY be used for signing. For many use cases, these will however not be the correct keys. For instance, if the use case is to provide non-repudiation of meter readings, the messages should be signed with a certificate stored in the calibrated measuring chip.

To be able to verify the digital signature, one needs to know which key was used to sign it. JSON Web Signatures supports several ways to store a key identifier with the signed message. As the certificates that can be used for signing are not specified, hash values will be used to identify them. Within the OCPP, the Charging Station and CSMS SHOULD include the field `x5t#S256` in the JWS Protected Header to identify the certificate. Following the JSON Web Signatures standard [\[RFC7515\]](#) the value of this field SHOULD be set to the SHA-256 hash of the DER encoding of the signing certificate. How stakeholders can look up the certificate based on the hash value is out of scope for this document.

### NOTE

In the set up with a Local Controller, described in [Local Controller](#), the TLS client key that would be signing messages to the CSMS will, in fact, not be the TLS client key that the TLS connection is using, since the key in the Local Controller is different from that in the Charging Station. Similarly, the TLS server key signing messages will be that of the CSMS, not that of the local controller. Therefore, implementation of the protocol MUST NOT regard this mismatch as invalidating the signatures; in fact, it is an expected and desired property to provide end-to-end authenticity.

## 8. Configuration

The following Configuration Variables are added to control JSON/WebSockets behaviour:

### 8.1. RetryBackOffRepeatTimes

Required	yes		
Component	componentName	OCPPCommCtrlr	
Variable	variableName	RetryBackOffRepeatTimes	
	variableAttributes	mutability	ReadWrite
	variableCharacteristics	dataType	integer
Description	When the Charging Station is reconnecting, after a connection loss, it will use this variable for the amount of times it will double the previous back-off time. When the maximum number of increments is reached, the Charging Station keeps connecting with the same back-off time.		

### 8.2. RetryBackOffRandomRange

Required	yes		
Component	componentName	OCPPCommCtrlr	
Variable	variableName	RetryBackOffRandomRange	
	variableAttributes	mutability	ReadWrite
	variableCharacteristics	unit	seconds
		dataType	integer
Description	When the Charging Station is reconnecting, after a connection loss, it will use this variable as the maximum value for the random part of the back-off time. It will add a new random value to every increasing back-off time, including the first connection attempt (with this maximum), for the amount of times it will double the previous back-off time. When the maximum number of increments is reached, the Charging Station will keep connecting with the same back-off time.		

### 8.3. RetryBackOffWaitMinimum

Required	yes		
Component	componentName	OCPPCommCtrlr	
Variable	variableName	RetryBackOffWaitMinimum	
	variableAttributes	mutability	ReadWrite
	variableCharacteristics	unit	seconds
		dataType	integer
Description	When the Charging Station is reconnecting, after a connection loss, it will use this variable as the minimum back-off time, the first time it tries to reconnect.		

### 8.4. WebSocketPingInterval

Required	yes		
Component	componentName	OCPPCommCtrlr	
Variable	variableName	WebSocketPingInterval	
	variableAttributes	mutability	ReadWrite
	variableCharacteristics	unit	seconds
		dataType	integer
Description	<p>A value of 0 disables client side websocket Ping / Pong. In this case there is either no ping / pong or the server initiates the ping and client responds with Pong.</p> <p>Positive values are interpreted as number of seconds between pings.</p> <p>Negative values are not allowed, SetConfiguration is then expected to return a <i>Rejected</i> result.</p> <p>It is recommended to configure WebSocketPingInterval smaller then: MessageAttemptsTransactionEvent * MessageAttemptIntervalTransactionEvent. This will limit the chance of the resend mechanism for transaction-related messages being triggered by connectivity issues.</p>		