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# The future of vendor-agnostic charging network diagnostics enabled by OCPP 2.x

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**Executive Summary**

The Open Charge Point Protocol (OCPP) is the leading standard for EV charging networks, ensuring interoperability between charging stations and backend systems. The shift to OCPP 2.0.1 is gaining momentum and promises enhanced diagnostic capabilities. This could help the industry to overcome current challenges with reliability and customer experience by enabling a much deeper level of diagnostics which is described in this paper. However, the transition is complex, with manufacturers focusing on transferring existing features before fully implementing new functionalities. Industry collaboration is crucial for the success of advanced diagnostics in OCPP 2.0.1 and onwards, as vendors currently prioritize proprietary diagnostics over vendor-agnostic features. Industry showcases could help guide broader adoption.

*AC & DC charging technology, Fast and Megawatt charging infrastructure, Standardization, Trends & Forecasting of e-mobility, Charging Business Models*

## 1 OCPP in charger network operations

OCPP (Open Charge Point Protocol) is widely recognized as the current de-facto standard for electric vehicle (EV) charging networks. It facilitates interoperability between charging stations and backend systems, allowing operators to manage charging infrastructure across diverse equipment from different manufacturers.

### 1.1 Status Quo

Today, most charging networks use protocol version OCPP 1.6J, which was published in 2015. It provides essential features such as remote start/stop, status monitoring, and asset management, enabling reliable and flexible control of charging stations. Although newer versions of the protocol exist, OCPP 1.6 remains popular due to its widespread adoption and compatibility with the existing infrastructure. While this version of the websocket-based protocol covers all the basic functionalities needed to run a charging network, many features have reached the markets after its release and are not supported natively. For instance, the need for improved security as well as support for Plug & Charge based on ISO 15118 are important topics that need to be handled by extending the protocol using custom messages (called Data Transfer). Though Open Charge Alliance who publishes and maintains the standard has addressed these aspects with white papers and application notes [1], for native support with specifically designed messages, OCPP 2.0.1 is needed. Among other things, the way that charging station operators can monitor their network and diagnose issues has been improved significantly with the introduction of the device model. The newer version does not only cover additional features but also entails changes to existing aspects, which is why it is not backwards compatible with 1.6. The following chapter addresses the changes and additions between version 1.6 and later versions (from 2.0.1 onwards, OCPP versions are backwards compatible and commonly referred to as OCPP 2.x)

## 1.2 The leap to OCPP 2.x

While the first edition of OCPP 2.0.1 was published in 2020, it was not immediately popular in practice. The significant resources required to implement the new version were not prioritized by companies developing charging station firmware and management systems. The shift from version 1.6 is now starting to take place. In addition to the growing demand for the extended range of supported features, this change is also driven by evolving legislation aimed at supporting the expansion and modernization of EV infrastructure. Several governments and regulatory bodies have been introducing mandates or funding requirements that specify the implementation of OCPP 2.0.1, first and foremost the NEVI program in the United States [2]. OCPP 2.0.1 has recently been accepted as an IEC standard [3] and subsequently voted as a CENELEC standard [4], which enables the European Commission, another impactful legislator, to also mandate it as a standard. This would further accelerate the version upgrade in the European market.

To get a better understanding of the changes, the rest of this chapter will look at different functional blocks defined by the protocol to explain new additions as well as significant changes to the messages and logic of the protocol with regards to monitoring and diagnostics of chargers in the field. A complete overview of functional blocks can be found in figure 1.

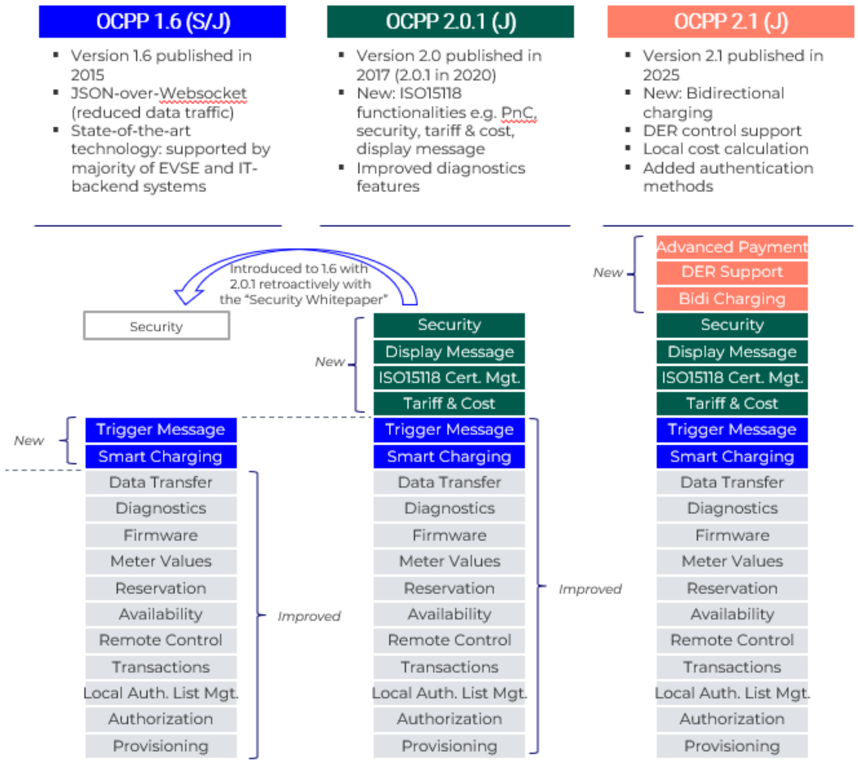


Figure 1: Overview of OCPP features based on functional block logic of version 2.x. Source: P3

### 1.2.1 Device model

OCPP 2.0.1 was the first version of the protocol to introduce the concept of the device model. This concept is present across various messages and functional blocks. It allows chargers to report information on a more detailed level than previously possible. Each charging device reports a list of components to the backend, and each component can have multiple variables associated to it. Each variable has certain attributes such as mutability (Read/Write) or supportsMonitoring (to indicate that a variable can be used for monitors, further explained in chapter 1.2.6). All this means that the operator is given the transparency to see what components the charger exists of. The device model concept is leveraged in many messages and can be used for different purposes. A simple example would be viewing and changing settings. Being able to associate a certain component to a message enables significant monitoring improvements, since a standardized way to report information for dedicated components did not exist in OCPP 1.6. The new opportunities given are explored in more detail in section 1.2.6.

### 1.2.2 Provisioning

In this functional block, a charging station can not only get and set variables (similar to the configuration messages in earlier versions), but requests device model information as a report. Resets also fall under this block, and it is notable that the differentiation between hard and soft resets has been removed. Depending on the implementation, hard and soft resets requests have rather different effects for many stations in 1.6, and differences in boot times between the two versions can be observed. Lastly, a completely new feature is the ability to change to a different backend altogether. The ability to create network configurations and assign them with priorities makes this possible.

### 1.2.3 Transactions

Transaction handling is a crucial function of OCPP and an area that has been changed significantly in OCPP 2.x. It is one of the main reasons why there cannot be backwards compatibility with earlier versions. A fundamental change is the fact that the backend is no longer the party assigning the transaction Id. This is now done by the charging station. To monitor an ongoing transaction, the new transaction event messages contain details that enable the operator to gain more insights about the charging session. This includes a trigger for each transaction event, making transparent why the event was created. This means that user actions like authorizing and plugging in can be distinguished. Transaction events also show if the charging session was started offline, another aspect adding monitoring value. Each transaction event is numbered sequentially, so charging sessions can easily be analyzed step-by-step by looking at sequential transaction events.

In OCPP 1.6, the operator was mostly dependent on analyzing status and start/stop transaction messages to monitor charging sessions, which did not provide the same amount of depth. For instance, it was not possible for the operator to determine why a station went into “preparing” status. StatusNotifications are still present in OCPP 2.0.1, but the list of possible statuses has been simplified. Instead of sending a dedicated status notification, the status of a connector can now also be changed by leveraging the device model using the variable “AvailabilityState”.

Transactions cannot just be monitored more closely. There is also improved clarity and transparency about why the charging session was initiated and stopped. The variable “TxStartPoint” lets the operator configure at what point a transaction should actually start. Several start points are predefined, the earliest being when a vehicle is detected in the parking bay and the latest when energy is being transferred to the vehicle. Similar options exist for “TXStopPoint”.

### 1.2.4 ISO 15118 support

A prominent improvement of OCPP 2.x is native support for plug and charge using ISO 15118. This functionality has been added to the authorization functional block, in which it is defined how charging stations can pass on the certificate information from the vehicle towards the backend for Plug and Charge authorization. In addition, there is a separate functional block for certificate management covering aspects such as installing leaf certificates on the charging station in order to establish ISO communication with vehicles.

In addition to plug and charge, ISO15118 also enables the exchange of charging schedules between vehicle and charging station. This is relevant for OCPP, as it impacts smart charging. Hence, the smart charging functional block includes several use cases for ISO 15118 based smart charging. The charging station can inform the backend about updated schedules using newly defined messages.

### 1.2.5 Security

OCPP 1.6 did initially not emphasize security, leaving risks for potential cyberattacks. To combat this, an extensive white paper [5] was published introducing three security profiles, the most secure of which requiring certificate-based TLS authentication from both backend and charging station side. OCPP 2.x natively supports these added security measures.

### 1.2.6 Diagnostics

After the most important general changes between OCPP versions have been explained, we can have a closer look at diagnostics. As explained in chapter 1.2.1, the device model enables operators to have a much more granular look at their charging infrastructure by enabling the charging station to communicate on a component level. OCPP-based monitoring and diagnostics in earlier versions largely depended on analyzing error codes, which was limiting both due to the non-standardized nature of error codes and the need for the charging station to update its status to convey error information. A standardized mechanism to report multiple events at the same time was not available. Now, a charging station can send NotifyEvent messages, which precisely address these two shortcomings:

- It is possible to report an incident or failure of a given component independently of the connector's or charging station's overall status
- Multiple events or failures can be present at once, instead of just one error code at a time

NotifyEvent messages still give implementers the opportunity to include manufacturer-specific error codes, but also contain a lot of other data points. The variable "problem" gives implementers a way to flag issues that can be processed by the CPMS to highlight affected components. Besides the required allocation to a component and variable, further data points important for monitoring and diagnostics include the possibility to link to a previous event as a cause and to "clear" a situation when it is no longer a risk.

All of these aspects present a significant improvement over OCPP 1.6, which often left operators wondering about the source of the error and its impact on the charging station, especially in cases where the implementer did not deem the situation severe enough to set the charging station to a "faulted" status. However, the features defined in the OCPP 2.x diagnostics functional block go even deeper.

Simply put, it enables the operator to specify under which circumstances the charging station should send alerts. This is another fundamental change compared to OCPP 1.6, where the CPO was fully dependent on the implementation of the charging station. Individual settings that control the sending of alerts in the form of NotifyEvent messages for a given component are called monitors. The implementer can "hardcode" certain monitors and suggest additional ones, but the CPO has the ability to configure custom monitors for any component that supports it.

There are two steps to configuring alerts. The simpler one is to select a monitoring base, of which there are three types:

- HardWiredOnly – only shows alerts that the charging station must sent as per its OCPP implementation
- FactoryDefault – activates the default monitors recommended by the manufacturer
- All – activates all monitors configured by the manufacturer

However, since the operator has transparency over what components and variables exist, it is also possible to create completely custom monitors that are not pre-configured at all. This can be done by sending a SerVariableMonitoringRequest message defining the circumstances under which the monitor should be triggered. This can be either periodically or when reaching a certain threshold or delta. For example, an operator interested in the temperature readings of a high-power charging cable could configure a monitor to send a sensor reading every 5 minutes, and to immediately alert when the temperature reaches the threshold of 85°C. To distinguish between monitors that are meant to inform the CPO, and those who require attention quickly, a severity between 0 and 9 must be defined for each configured monitor (the lower the number, the higher the severity). The operator can also choose to only receive alerts for monitors above a configured severity. Examples of different types of monitors configured by a CPO for can be found in figure 2.

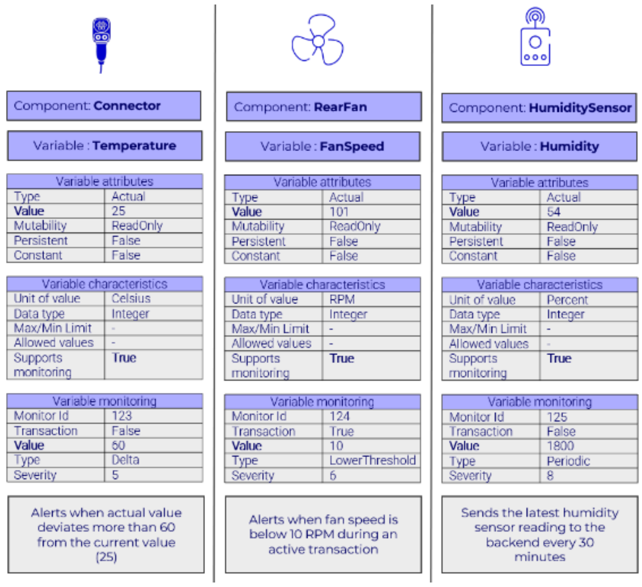


Figure 2:Exemplary monitors of different types

# 2 What stands in the way of OCPP-based diagnostics

The advanced features of the diagnostics functional block theoretically have the potential to enable CPO to deepen their diagnostic capabilities and improve uptime by reacting to failures more quickly, in a more targeted way. They could even use the additional monitoring data to leverage predictive maintenance and detect failures before they occur. In practice, there are several factors that contribute to this not being the case yet. It is not certain that the diagnostic functional block will be used to its full potential, in the foreseeable time. This chapter will explain why this is the case.

## 2.1 Why diagnostics haven't reached their full potential

OCPP 2.0.1 is significantly more complex to implement. Therefore, charging station manufacturers are not implementing the entire feature scope at once, but have instead been focusing on transferring existing features to the new protocol and pass core and advanced security certification, which is required in certain markets as well as in some tenders. This is only logical but means that there is no immediate need to implement all available monitoring capabilities.

Furthermore, even if a manufacturer implements all functionalities of OCPP 2.0.1, this does not mean that operators can use diagnostics to the full extent. There is no guarantee that all components that are of interest are represented in the device model, and certainly not that all available data can be accessed by obtaining the value of variables through pre-configured or custom monitors. For actual detailed diagnostics, sensor readings need to be ingested, and most manufacturers have not made this data available to their customers via OCPP yet. It is in their control to share this data, and there are no requirements to openly present this data.

## 2.2 Manufacturers lack incentives to embrace full functionalities

In fact, it can be against the interest of the manufacturer to share diagnostic data. Including all possible sensor readings and other data points into the OCPP implementation would require additional development effort. In addition to these added costs, there is also revenue to be lost. Charging station manufacturers increasingly offer service packages to operators. Depending on the offer, this may cover in-field repairs and maintenance, or just remote support. Either way, expanding their own diagnostics and maintenance capabilities are understandably of higher priority to manufacturers compared to a thorough implementation of an OCPP functional block that may not be used by all customers.

Especially in high power charging, it is common that charging stations not only communicate to the operator via OCPP but are also connected to a manufacturer backend using a proprietary communication channel based on MQTT. This means that in reality, an alternative route for diagnostic data already exists for most charging stations, and manufacturers are working on improving their own diagnostics. The software tools built based on proprietary diagnostic data are used to fulfill manufacturer service obligations as described above but can also be made available to the customer (operator) as an additional service, in which case there likely is no need for OCPP-based diagnostics.

A third way in which manufacturers can benefit from their proprietary diagnostic data is through a data-as-a-service model, in which an operator purchases diagnostic data to integrate in their own suite of software tools. This is an offer that makes sense for technically advanced operators, so it is generally not part of the baseline offer, unlike the OCPP capabilities of the charging station.

In addition to these (mostly economically driven) considerations, there could also be practical elements to consider: while the device model has added a standardized framework for passing on diagnostic data, this standard might not fully match with the way that developers of the charging station approach diagnostics. For example, there might be more levels of hierarchy within their approach compared to the three-tiered model (Charging station →EVSE → Connector) that OCPP 2.x uses. It could also be difficult to outline interdependencies between variables or preventing operators from drawing conclusions from certain monitors without added context. If manufacturers cannot entirely translate their own logic into the device model, it is plausible that they stick with proprietary data.

For the reasons listed in this chapter, it is unlikely that manufacturers will fully embrace the possibilities OCPP 2.0.1 has created for diagnostics. While it is expected that more advanced use cases within the protocol, such as the advanced diagnostics functional block in question, will be added to many chargers in the coming years, the market does not provide incentives to share detailed diagnostic data.

# 3 Potential paths towards vendor-agnostic diagnostics

Given the market reality and timelines described in chapter two, there is still time for industry members and regulators to figure out the future of diagnostics. A dialogue is needed here to align on the way forward, because it is not clear yet to what extent the OCPP advanced diagnostics functional block will be utilized. From a macro perspective, vendor-agnostic diagnostics would reduce overall development effort, as there are more backends than manufacturers in the market. This chapter explores potential factors that could promote OCPP-based diagnostics and create an incentive for in-depth implementations in the future.

## 3.1 EU Data Act

Regulations like the EU Data Act, aimed at ensuring fair access to data generated by connected devices, would be one way to incentivize manufacturers to implement OCPP-based diagnostics. Under the Data Act, operators and third parties must be able to access relevant technical and operational data, including maintenance and fault information, in a structured and machine-readable way using open standards where possible [6]. If manufacturers do not implement diagnostics, they may fall short of the Data Act's mandates for transparency and data accessibility, potentially facing regulatory penalties or market exclusion.

While the Data Act might be interpreted as an obligation to use the diagnostic capabilities of OCPP 2.x, it is not clear yet how exactly it will apply to the electric vehicle charging ecosystem, and industry-specific clarifications are needed before the Data Act's main provisions become applicable in September 2025. Given the complexity of (DC) charging infrastructure, it seems highly unlikely that manufacturers could be enforced to share all theoretically available data. Nonetheless, it is plausible that the data act could overall improve the practice of sharing data that helps CPOs operate their network, even if it does not go as deep as would be possible.

## 3.2 Increased adoption of OCPP 2.x

As mentioned in chapter 1, both regulatory aspects as well as new features are causing a growing share of the market to make the transition to OCPP 2.x. The recent release of OCPP 2.1, which supports bidirectional charging and solutions for integrated payment terminals, could further accelerate this development. Once a large share of charging networks runs on OCPP 2.x, we can expect the market to mature and operator's requirements to become more rigid. With increasing pressure from customers in a market that is generally consolidating, sharing diagnostic data openly could become one way for manufacturers to differentiate themselves from the competition. While smaller CPOs likely don't have the resources to build sophisticated diagnostic capabilities, larger CPOs with specialized operational staff and software are generally interested in increasing control of their value chain and might push manufacturers to share more data using OCPP 2.x, once it has become more prevalent in the market. However, this is just one possible scenario, and it would only apply to a subsection of manufacturers needing to distinguish themselves in a competitive market. It is much more unlikely for established, large manufacturers.

## 3.3 Industry showcases

Despite the current trend towards proprietary manufacturer data described in section two, sections 3.1 and 3.2 have identified possible paths forward for OCPP-based advanced diagnostics. To support this open approach, industry showcases could display what is possible. This could be beneficial as the market is still in the process of adopting the new protocol version and conclusive examples are needed to prioritize development when several technologies in the charging industry are still in the early stages.

We suggest two steps to approach a successful industry showcase:

1. Implementation guidelines with minimum requirements
2. A pilot project with open data

Many industry-leading companies should ideally be included in creating the implementation guidelines to underline their importance. While the implementation of monitors by itself is fairly straightforward, there are a number of questions that could be addressed and help developers with implementation, including

- A (minimum) list of components that the charging station should be reporting
- A (minimum) list of variables for which monitoring should be supported
- Guidance on which variables to include in preconfigured and hardwired monitors
- Severity categories for commonly occurring monitoring events

The guidelines should consider the hardware in question, as components differ greatly between different kinds of charging stations. Different archetypes could be defined.

It is important that these guidelines are published before most of the market has finished developing diagnostics. Past attempts to standardize error codes within the industry have only had limited impact, as manufacturers had already determined their approach and could not easily change it. Since certification for the diagnostics functional block has only recently been started, there is still time to do this.

For a successful pilot project, close collaboration between industry players is required. At least one manufacturer as well as charge point operator should take part. A CPMS provider is also needed unless the CPO has a self-developed backend. The pilot should take place with actual chargers in the field. To show successful examples of improved operations, actual events and observations on site need to be documented alongside the diagnostic OCPP messages and how they are processed by the CPMS. This way, the impact of diagnostics can be made transparent. As an example, if a pattern of increased temperatures has been visible before the failure of a component, this would showcase the ability of OCPP diagnostics to alert the CPO at an early stage.

# 4 Conclusion

Making the leap from OCPP 1.6 to OCPP 2.0.1 is a major step for charging networks. The new protocol version includes many improvements and additional features, including native support for plug & charge and advanced security, improved transaction handling and a device model that enables component-level monitoring.

Monitoring has been significantly advanced, since more details about the charging station and its parts as well as the actions of the EV driver have been made more transparent. Decoupling StatusNotifications and error messages have resolved one of the key weaknesses of OCPP 1.6 when it comes to diagnostics, and the new NotifyEvent message is much more useful than just an error code by itself. However, the diagnostics functional block, which adds the capability to create custom monitors, is no priority among manufacturers as of now. This is due to the lack of incentives to implement it thoroughly (using as much sensor data as possible), when they could instead focus on proprietary solutions that could generate additional revenue.

It is uncertain if the diagnostic capabilities of OCPP 2.x will be fully leveraged in the long run. This would require collaboration and commitment from many industry members. Showcases have been proposed to provide guidance to market players and potentially establish an approach towards full use of OCPP diagnostics.

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# Presenter Biography

Niklas Knutzen is a senior consultant at P3 group focusing on charging technology and operational excellence. He has accumulated experience in this specific field during more than 3 years working on different projects with previous experience in the automotive and aviation sector. His work at P3 has included fast charger maintenance and spare parts cost optimization, the development standardized data requirements for CPOs, the roll-out of digital maintenance platforms and the assessment of charging equipment suppliers. He works closely with the Open Charge Point Protocol and represents the P3 group at the Open Charge Alliance, which develops the industry standard. He studied Business & Engineering with focus on production processes at Clausthal University of Technology.

Lukas Schriewer leads the Charging Technology & Network Operations team at P3 Group. For more than 10 years he has gained in-depth expertise in the areas of product development for charging hardware and software solutions, interoperability testing of charging infrastructure (EV – EVSE – Backend) and operational excellence for network operators. During this period he worked with automotive OEMs, HW manufacturers, CPOs, MSPs and utility companies. His daily work also focuses on the design of technology roadmaps, the development of smart maintenance models and the strategic supplier evaluation for charging infrastructure products and services. Before joining P3, he has studied industrial engineering at RWTH Aachen University (Germany) and Polytechnic University of Turin (Italy).