Integrating OCPP Chargers at Filling Stations

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OCA White Paper

Relevant for OCPP version: 1.6 and 2.0.1.

This paper has been written with input from OCA members in the task group "OCPP & Fuel Stations".

Abbreviations

CPO	Charge Point Operator. Synonymous to CSO.
CS	Charging Station
CSMS	Charging Station Management System. Back-office system through which a CSO manages the charging stations.
CSO	Charging Station Operator. Party managing the network of charging stations.
EMSP	Electro-mobility Service Provider. Party that provides a charging contract to the EV driver.
EV	Electric Vehicle
ISO 15118	A standard protocol used between EV and charging station.
MSP	Synonymous to EMSP
OCPI	Open Charge Point Interface. A standard protocol to exchange roaming information between CSO and EMSP.
OCPP	Open Charge Point Protocol. A standard protocol used between charging stations and CSMS.
POS	Point of Sale system. System that processes sales and payment transactions at the point of purchase.

1. Abstract

The number of electric vehicles is growing rapidly and filling stations will have to adapt sooner or later by providing electric charging services in their forecourt. A filling station retailer can install and manage the charging stations at his site himself, but he can also choose to let his chargers be managed by a charging station operator (CSO) or even fully outsource all charging business to another party. In the latter case there will be no integration with any system at the filling station, and paying for charging in the shop will not be possible. In the other cases an integration with the point of sales terminal in the shop can be made, such that the user experience of charging can mimic that of regular fueling: charge first and then pay in shop.

OCPP is the defacto standard protocol to communicate with charging stations. This paper shows how an OCPP charging station and a CSO back-end can be integrated with a point of sales (POS) terminal of a filling station, and what the flow of information is for the various payment options. Integration with a POS can be achieved via a roaming protocol that connects to the charging station management system (CSMS) of the CSO or via a local controller that sits between POS and charging station.

With such an integration in place, payment at the shop is possible, and data about charging activity becomes available in the POS and the retailer's back-office.

Although this paper is specifically targetting the integration of chargers at filling stations, the principles outlined here are also valid for other point of sales situations, like hotels or supermarkets.

2. Introduction

The number of electric vehicles is growing rapidly. After 2030 several countries have banned the sale of internal combustion engine cars. This inevitably means that if existing filling stations do not start to adopt electric charging stations, they are doomed to become a niche market, since internal combustion engines are slowly fading out.

In the beginning electric vehicle charging and traditional filling stations were totally separate activities, executed by separate companies. In October 2017 Shell took over the charging network of NewMotion, which can be seen as one of the first movements of the traditional filling station market investing in electric vehicle charging. Since then, things accelerated, and currently almost all big oil and gas companies invest one way or the other in electric vehicles charging business and infrastructure across the world.

Companies realize that vehicles will be more and more electrified, pushed by the climate situation and government policies. First personal vehicles, but now also vans, busses, and even trucks are electrified, which requires a large amount of charging infrastructure. Although a fuel pump and a charge station are both used to supply vehicles with energy, they are totally different devices with a different type of usage and different type of management. A few of the characteristics of electric vehicle charging stations are:

- They are made for unmanned situations.
- Complexity of the stations requires remote control and management.
- Can be used with different charge cards from eMobility Service Providers (EMSPs) — there can be hundreds of different service providers.
- Location and availability data must often be published to external systems like National Access Points — this is an obligation in the EU.
- Are connected to charging station operator management systems (CSMS) and via these also connected via roaming protocols to eMobility Service Provider systems.
- They usually only have one external open connection, which is to the CSMS, through which all communication is channelled.
- Can be connected to flexible energy sources, like wind and solar, or to energy storage systems and energy management systems.
- The average charging time is considerably longer than fuel pumping, but charging times are decreasing as technology advances.

A traditional filling station is very different. In unmanned situations activation and payment is done direct via payment card devices connected to the fuel pumps. In manned situations, payment is done inside the shops, which requires a direct connection between the station and the shop payment system. They also have existing reporting systems which collect all kinds of information via the payment system, and although they do accept fuel cards from mobility service providers, this is often a limited number and not via external roaming and connection services. Many filling stations have a convenience store or shop that is an important source of income for the filling station owner or franchisee.

It can be a challenge to manage and use charging stations in an existing environment like filling stations. This document describes different approaches to this challenge.

It starts with a description of three different ways to manage your charging stations. Then the technical aspects are discussed that come into play when the charging stations and a CSMS need to integrate with a POS terminal or a forecourt controller. This is followed by an explanation of the process flow for different payment methods, which concludes with a brief description of two recent payment methods that are specific to electric charging: ISO 15118 Plug-and-Charge and AutoCharge.

2.1. Charging speeds

In recent years the charging speed of electric vehicles has increased enormously. Fast chargers (or rapid chargers) used to have a maximum power of 50 kW. Charging a 62 kWh battery to 80% then takes at least one hour. [1] Usually more, since charging rates slow down at higher states of charge. Charging technology in fast charging stations, as well as in electric vehicles, has advanced to a point where stations can deliver power up to 350 kW and some electric vehicles are able to charge with up to 250 kW. With that power a 62 kWh battery can potentially be charged to 80% in 10 minutes (assuming the power level remains at 250 kW all the time, which is not the case with current technology). This drastically reduces the charging time to a point where charging your electric vehicle in some cases does not take much longer than fueling an internal combustion vehicle.

A major difference between fast charging and fueling that should be noted, is the following. The majority of customers at a filling station fill up their fuel tank completely, because they have no other place where to fuel, but at filling stations. Drivers of electric vehicles will usually only fast charge during a trip for the amount of energy that they need. In many cases the electric vehicle can be charged at home or at the office to 100%. That is why charging during a trip, e.g. at a filling station equipped with charging stations, is often for much less than the battery capacity. This leads to a large variance in charging times. One customer might charge for only 5 minutes (enough to add around 100 km of range), while another customer stays for 45 minutes and decides to have lunch or take a nap in the meantime.

2.2. CSO, EMSP and roaming explained

The concepts of CSO, EMSP and roaming are heavily used in this document. This justifies a short explanation of these concepts.

A charging station operator (CSO) is a party that manages and maintains a network of charging stations. An e-mobility service provide (EMSP) is a party that provides charge cards to EV drivers that allow them to use the charging stations. These roles are often combined in the sense that a CSO also provides charge cards to EV drivers, thus performing an ESMP role. There are EMSP parties that only provide charge cards, just as there are some CSOs, that only manage charging station networks.

Roaming in this context is the act of allowing charge cards from different EMSPs to charge on a CSO’s network. In order to allow this, a CSO needs to set up a contract with each EMSP about pricing and other details. To make this technically possible, each EMSP partner needs to provide the CSO with a list of its charge cards and the CSO needs to send each EMSP partner the list of charging transactions that are associated with the EMSPs charge cards.

This information exchange can be done using "peer to peer" direct connections between CSO and EMSP. OCPI is a protocol that is often used for that. However, when a CSO has tens or hundreds of EMSP partners, then the overhead of setting up peer to peer connections can become an obstacle. A solution for this is to connect to a roaming hub. A roaming hub is a central system to which CSOs and EMSPs connect. The hub takes care of transferring the information between CSO and EMSP partners that have a roaming contract together. Well-known roaming hubs in Europe are: e-clearing.net, Gireve and Hubject.

The concepts explained above are comparable to the following concepts from the International Forecourt Standards Forum (IFSF), which apply to filling stations:

e-Mobility concept	IFSF concept
CSO	Merchant, such as Shell
EMSP	Issuer, such as DKV
Roaming	Agreement to accept third party fuel cards
Roaming Hub	Acquirer/Switching Host, that manages the routing of transactions from Merchants to Issuers.

2.3. CSMS explained

A charging station is connected to a charging station management system (CSMS). The charging station is the unit that provides the power to the EV to charge its battery. The CSMS is the system that the CSO uses to manage the charging station network. It authorizes users for charging, based on their contract or payment, and it gathers usage data for billing. It is the system that a CSO uses to remotely control the charging station. A CSO can, for example, remotely start or stop a charging session, reset the station or issue a firmware update. A CSMS also handles connections to EMSPs or roaming hubs, that are needed to allow users with charging contracts from other parties than the CSO. The CSMS is an essential component in a charging station network.

3. Managing charging stations at filling stations

A fuel dispenser is normally connected to a forecourt controller and POS system to control it and handle payments. The situation is similar for charging stations. They need to be connected to a back-office system: a CSMS (Charging Station Management System). Payment at charging stations in the public space is often achieved via charge cards from an EMSP. Charging costs are then invoiced to the customer by the EMSP.

When charging stations are installed at fuels station forecourts it may be beneficial to allow customers to pay at the cashier in the shop. One way to achieve this is to connect the charging stations to your local POS system, but that is not the only option. The following paragraphs discuss three possible ways to manage charging stations at a filling station.

3.1. Charging stations managed locally

A locally managed charging station is connected to the local POS via a (limited) CSMS system. This CSMS is only connected to the charging stations at the forecourt and the POS and has no other external connections. The amount of energy that a customer charges is communicated to the POS and customers pay in the shop with cash or credit, just as they would for fuel.

The CSMS only needs to support basic functionality needed for starting and stopping of charge sessions and reporting energy usage, and can therefore be fairly simple. Since a locally managed CSMS is not connected to EMSPs or roaming hubs, such a system can, however, not support the use of charge cards. Payment will have to take place in the shop or via an outdoor payment terminal.

The retailer CSMS can be physically located on-site and charging stations can be connected to the CSMS with a network cable to avoid any reliance on the availability of a cellular network.

NOTE	From a technical point of view there is no obstacle to connect a locally managed CSMS to a roaming network, but it is not practical. Connecting to a roaming hub requires a subscription, which is too costly for a very small charger network that is the size of a filling station. Peer to peer connections with EMSPs do not incur a subscription, but it will be too time-consuming for a retailer to set up contracts and maintain connections with many EMSPs.

Figure 1 below shows the parties that are involved in a local setup.

1. The *EV driver* can charge at the *Charging Station* with cash or credit card.
2. Payment takes place in the shop at the *POS*.
3. *POS* receives energy usage at *Charging Stations* via the *Retailer CSMS*.
4. The *Retailer* receives the payment directly from the *EV driver*.

Details of the transaction and payment will be discussed in chapter Typical payment scenarios for charging stations.

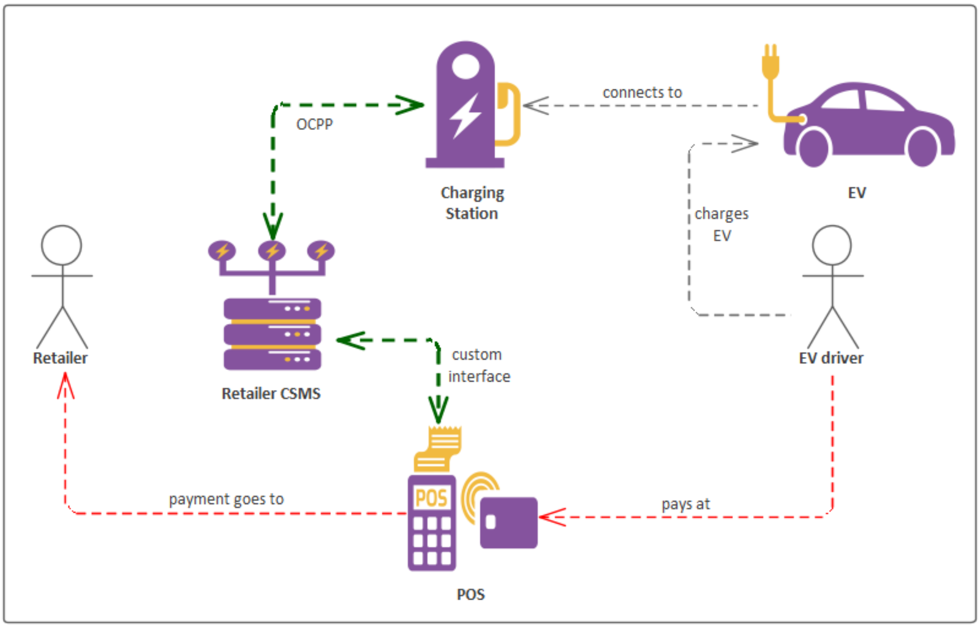


Figure 1. Parties and transaction flow with a retailer CSMS

When using this approach:

- Customer experience is identical to fueling;
- Retailer has a direct contact with customer;
- Customer is required to enter shop, which may lead to additional sales;
- CSMS needs only limited functionality and is therefore not costly;
- There is no reliance on availability of an internet connection or cellular network.

Downsides of this approach are:

- Customer cannot use an EMSP charge card or ISO 15118 Plug-and-Charge and AutoCharge for charging. This may cause some customers (e.g. company cars) to avoid the station.
- Charging station firmware cannot be updated remotely (unless the manufacturer has its own direct connection to the charging station).
- Retailer is responsible for monitoring the health of the charging stations and acting on any errors.

3.2. Charging stations managed by a CSO

Instead of operating the charging stations at the forecourt himself, a retailer can request a charging station operator (CSO) to do this for him. The retailer owns the charging stations and receives revenue from charging sessions, but pays the CSO a fee for the operational management of the charging stations. The charging stations are connected to the CSMS of the CSO via a mobile data communication network.

The CSO will have roaming contracts in place with EMSPs, either peer to peer or via one or more roaming hubs. As a result, EV drivers will be able to use their charge card at charging stations in the forecourt, but they can also opt to pay with cash or credit in the stop. A retailer can always opt to only allow payment in the shop, if so desired.

NOTE	Oil companies are expanding their business into the realm of e-mobility. Several of them are already offering CSO and EMSP services, like Shell (Shell Recharge), BP (BP Pulse) and TotalEnergies (EV Charge), and will thus be able to perform the CSO role mentioned in this document.

When the EV driver pays in the shop, then the situation is very similar to the diagram shown in Figure 1, the only difference being that the CSMS is no longer local. Figure 2 below shows how the full revenue of charging goes to the retailer, who pays a monthly fee to the CSO for management of the charging stations.

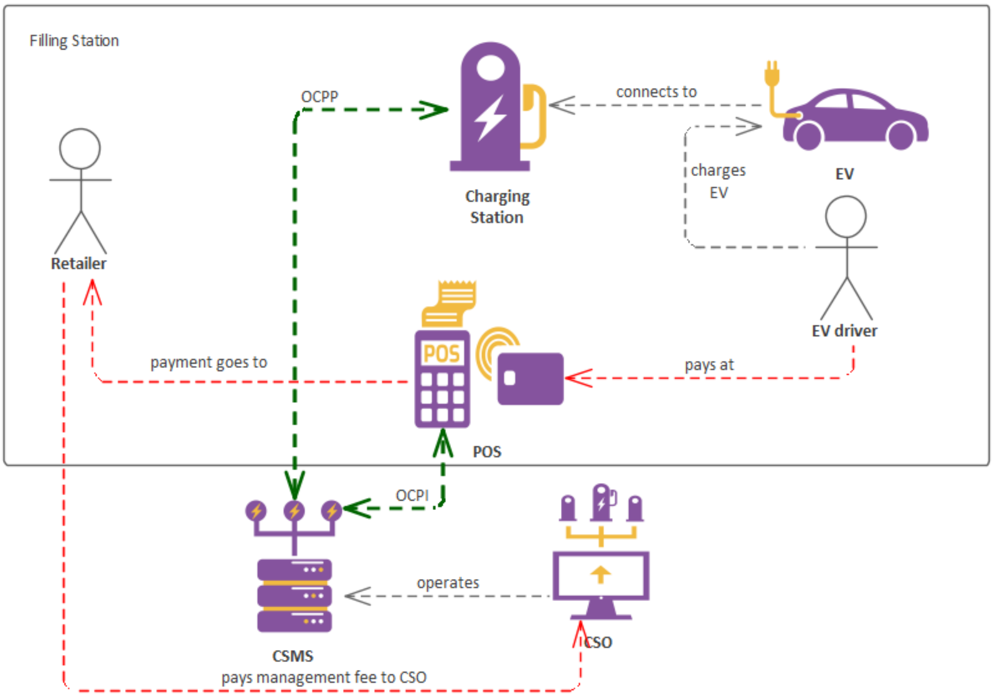


Figure 2. Parties and transaction flow when managed by a CSO and paying in the shop.

The financial flow changes when the EV driver use a charge card at the charging station, because it is the EMSP that has a contract with the EV driver, as shown in Figure 3. The retailer owns the charging stations and sets the price for charging. The EMSP likely has its own pricing towards the EV driver, which can be a simple surcharge on the retailer price or a completely different pricing model.

1. EV driver pays EMSP's price for charging to EMSP
2. ESMP pays retailer's price for charging to CSO
3. CSO pays charging revenue to retailer
4. Retailer pays (monthly) management fee to CSO

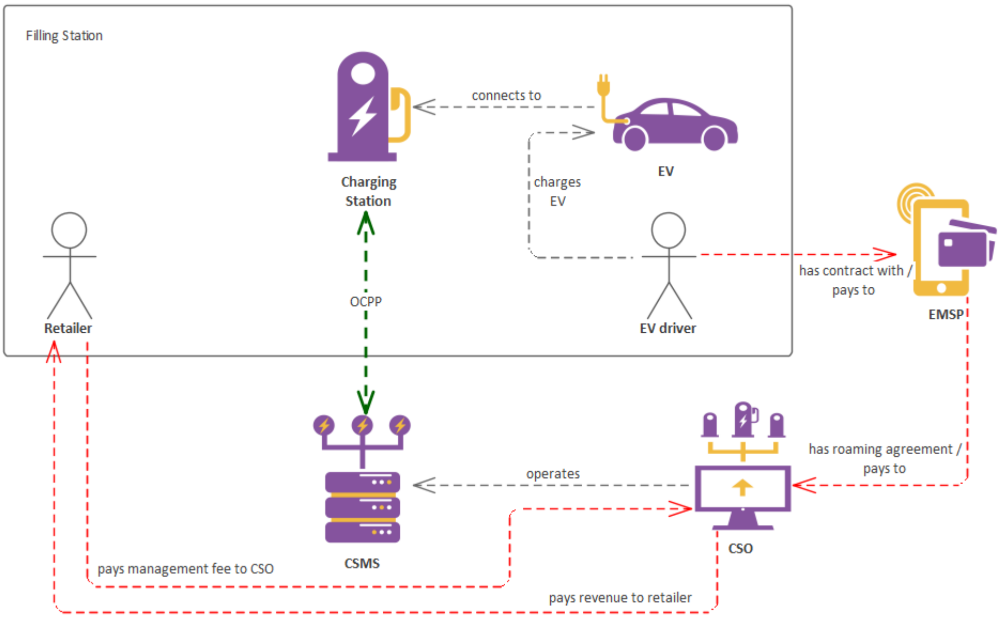


Figure 3. Parties and transaction flow when managed by a CSO and paying with a charge card.

When using this approach:

- Customer experience when paying in shop is identical to fueling;
- Customer can also use his/her familiar EMSP charge card;
- Customer can use ISO 15118 Plug-and-Charge and AutoCharge, when supported by charging station and EV;
- Retailer does not have to manage CSMS or charging stations, but a technical integration with the CSO is required;
- All charging revenue goes to retailer.

This solution relies for proper functioning on the availability of mobile data and internet connection. [2]

3.3. Charging stations fully outsourced to a CSO

Rather than owning charging stations and requesting a CSO to manage them, a retailer can also choose to completely outsource all charging services to a CSO. In that case the CSO owns the charging stations and takes all charging revenues. In return for letting the CSO operate charging stations at the retailer's forecourt, the CSO pays a monthly location owner's fee to the retailer.

Payment at the shop is no longer supported, because all revenue goes to the CSO, which means that payment has to be done via an EMSP charge card or a credit card terminal in the charging station.

When the EV driver pays with a credit card directly at the charging station, the revenue goes directly (via a payment service provider) to the CSO, as shown in Figure 4.

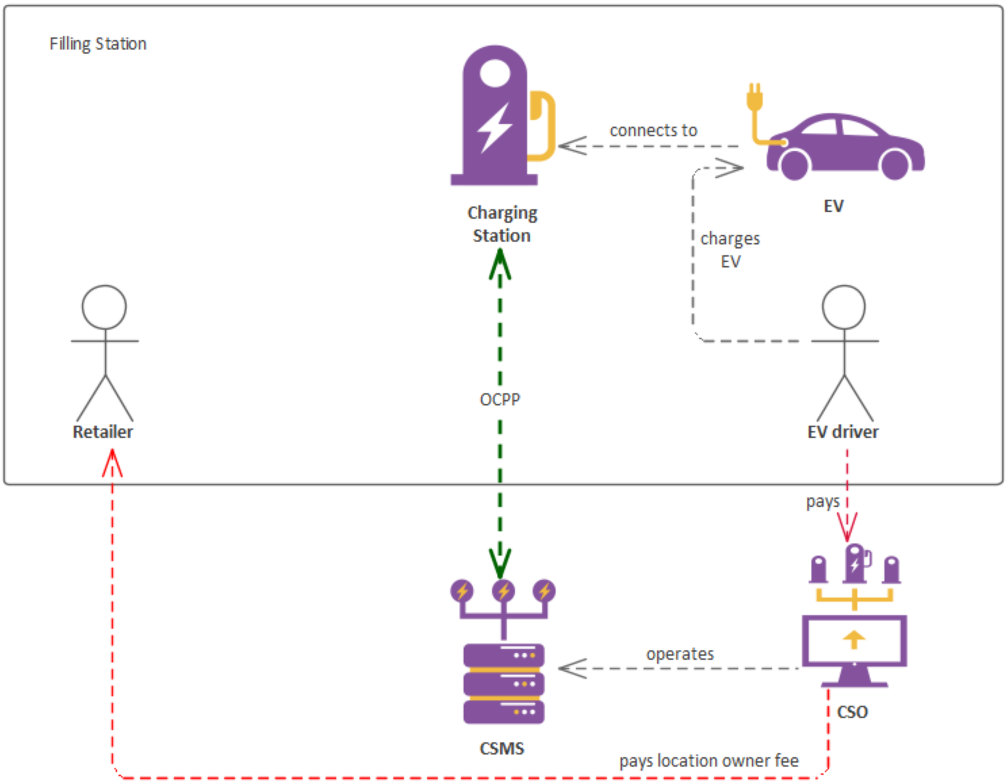


Figure 4. Parties and transaction flow when outsourced to a CSO and paying with credit card

When the EV driver uses an EMSP charge card at the charging station, then the steps in Figure 5 are as follows:

1. EV driver pays EMSP's price for charging to EMSP
2. EMSP pays CSO's price for charging to CSO
3. CSO pays retailer a (monthly) location owner fee

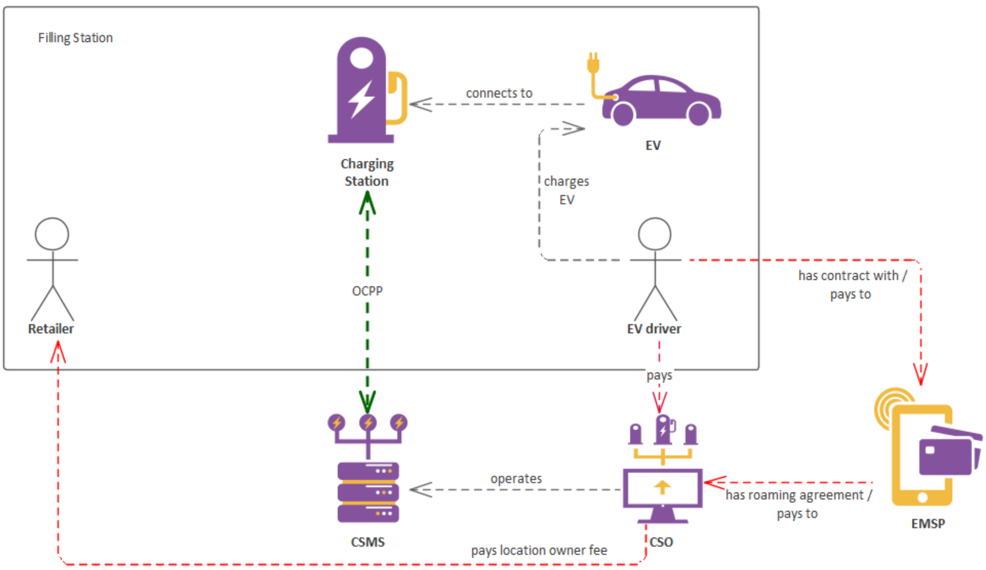


Figure 5. Parties and transaction flow when outsourced to a CSO and paying with charge card

When using this approach:

- Customer cannot pay in shop;

- Customer can use his/her familiar EMSP charge card;
- Customer can use ISO 15118 Plug-and-Charge and AutoCharge, when supported by charging station and EV;
- Retailer does not have to manage CSMS or charging stations;
- Retailer does not need to invest in charging station hardware;
- Retailer does not receive the charging revenue, but a location owner fee.

This solution relies for proper functioning on the availability of mobile data and internet connection.

4. Technical integration with the managing CSO

When charging stations are outsourced to a CSO, there is no dependency with any system from the filling station; the charging stations are fully controlled by the CSO and just happen to be located at the filling station. However, for charging stations that are owned by the retailer and managed by a CSO, an integration of the filling station's POS system with a CSO system is needed.

There are two different approaches to achieve this integration. They are described in the following sections.

4.1. Using an on-site local controller

A local controller is a concept from the OCPP protocol, which is used between charging station and CSMS. A local controller acts as a local mini-CSMS to — as the name already suggests — locally control a group of charging stations. This local controller speaks standard OCPP to the charging stations and the CSMS, but it is also equipped with an interface to the POS system of the filling station. It is depicted in Figure 6. Through this interface the POS system gives permission to start charging and receives the amount of consumed energy from the charging stations. (See also Paying in the shop after charging (postpaid)).

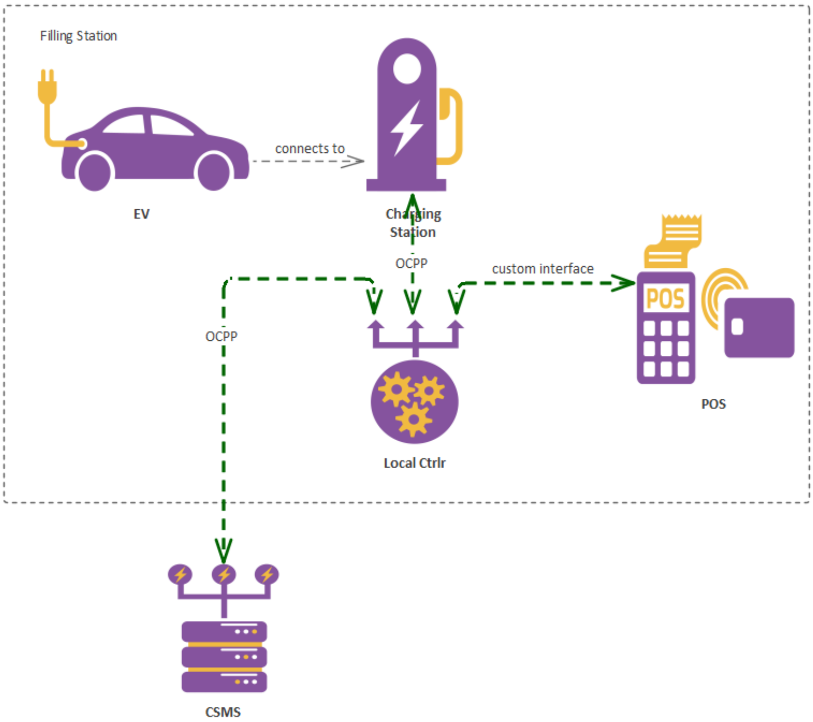


Figure 6. A local controller at the filling station to communicate with CSMS of CSO

The local controller is located on-site and connects directly to the charging stations and POS via a local area network. This means that charging services can continue to work even when connection to the internet is lost. It also has the advantage of low latency (no delays) in the communication between POS and charging stations.

Note, that a local controller is not (yet) a component that can be purchased off the shelf and may have to be custom developed.

4.2. Using a roaming protocol

An alternative integration that does not require additional on-site equipment, is to use a standard roaming protocol to communicate with the CSO. Roaming protocols allow an EMSP to request the CSO to start a charging session remotely, for example when a user starts a session via a mobile app, and to get updates on the amount of kWhs charged. A similar mechanism can be used by a POS system to allow a customer to start charging and to get updates on the amount of energy charged.

The diagram in Figure 7 shows a connection between a POS system and CSMS using the OCPI protocol. OCPI is only an example of a roaming protocol that can be used for this purpose; it is certainly not the only possible solution.

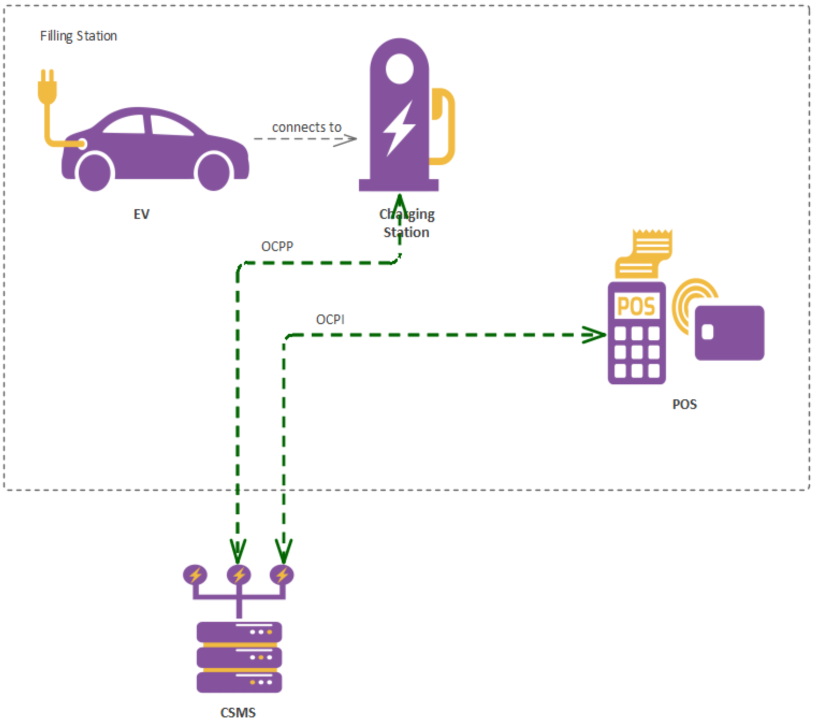


Figure 7. A POS using OCPI to communicate with CSMS of CSO

A CSMS often already supports OCPI (or similar) protocols. Only the POS system needs to be extended with a limited set of messages of the roaming protocol. In contrast to the local controller, which can be accessed via the local network, the communication between POS and CSMS is done via the internet. This may introduce some latency and vulnerability to network outages.

5. Typical payment scenarios for charging stations

Depending on how the charging stations are integrated with the filling stations, various payment scenarios are possible. This chapter dives into the details of exactly which messages need to be exchanged between the various systems for each payment scenario. These messages are shown in so-called sequence diagrams. These diagrams list a number of systems (actors) on the top with horizontal arrows denoting messages that are sent between them. The sequence of messages is from top (first) to bottom (last). The OCPP messages in these diagrams are for OCPP 2.0.1, but similar messages exist in OCPP 1.6.

5.1. Using an EMSP charge card or charge app

The simplest sequence diagram is that of payment using an EMSP charge card, because in that situation no communication with a POS system is needed.

Figure 8 shows messages when a local controller is used to integrate with a POS. This looks more complicated than it is: all the local controller does, is forward messages between charging station and CSMS.

The following steps are performed in the sequence of messages:

1. Charging station requests authorization of the charge card
2. Charging station starts a charging session upon approval of charge card
3. Charging station reports intermediate updates of energy consumption
4. Charging station finished charging session and reports total energy consumption

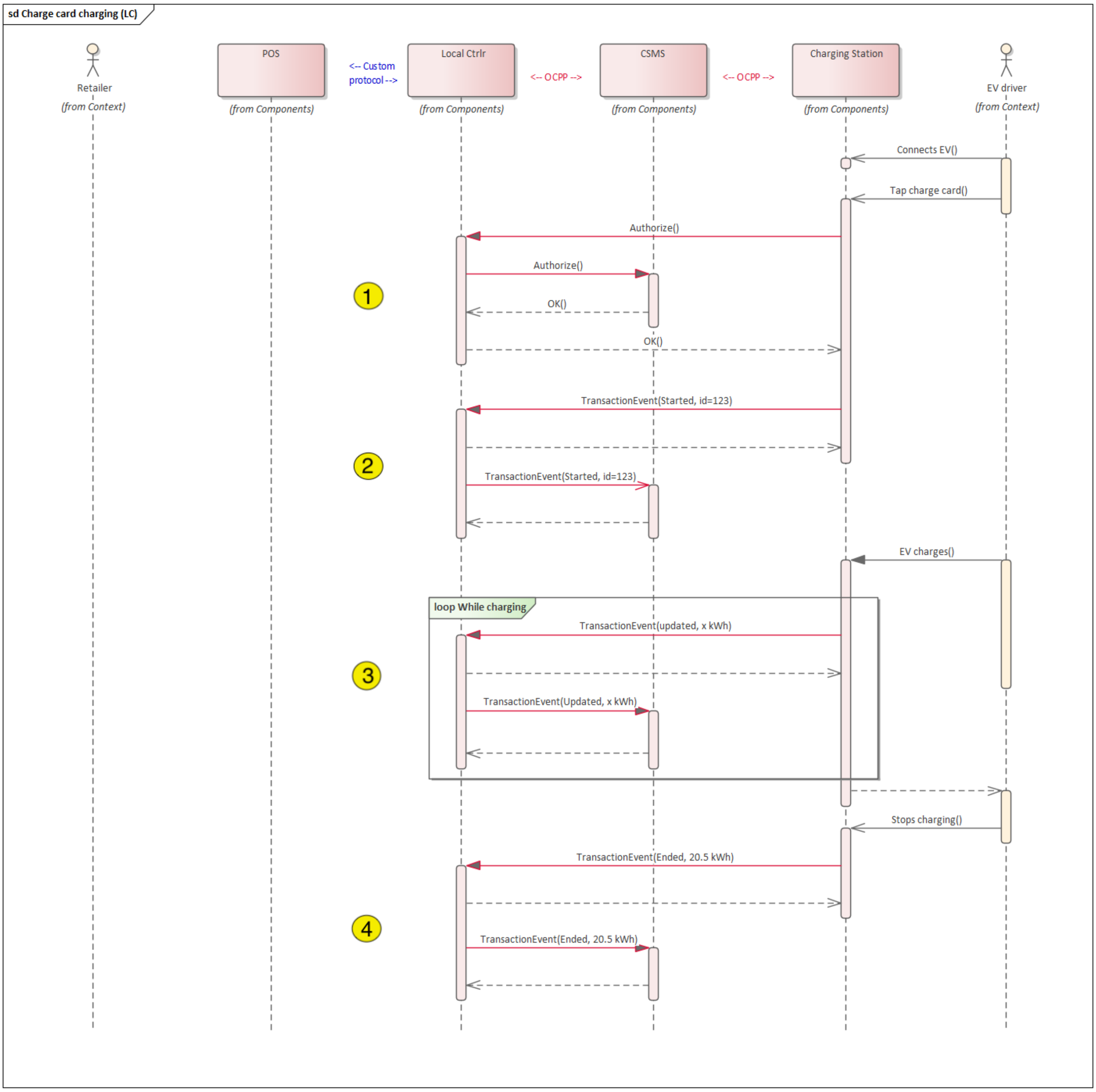


Figure 8. Charging using EMSP charge card (Local Controller)

In case of an OCPI integration (or some other roaming protocol) the same steps are performed, but no interaction is needed with any system from the filling station. Only messages between charging station and CSMS are exchanged. See Figure 9.

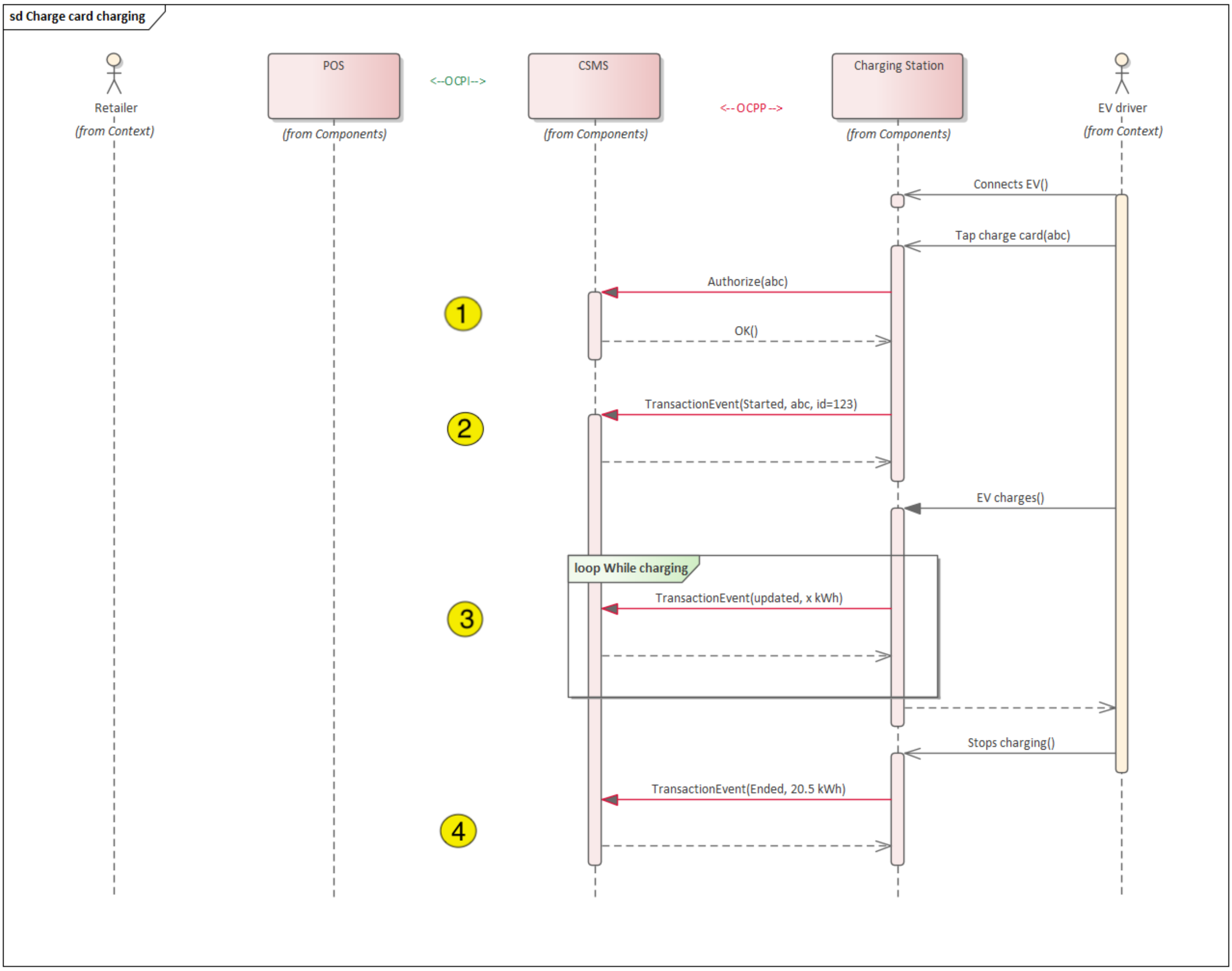


Figure 9. Charging using EMSP charge card (OCPI)

5.2. Paying in the shop after charging (postpaid)

In situations where the forecourt supports payment of a charging session at the cashier in the shop, an integration is required between the charging station and the POS system. The following sequence diagram in Figure 10 shows the message flow in a system that has been set up to mimic the process of using a fuel dispenser: When the customer connects the EV to the charger, the cashier needs to give permission to charge. This is analogous to the situation where, when the fuel hose is taken out of its holster, the cashier has to give permission first, before any fuel is pumped into the vehicle.

The CSMS from the CSO is not needed in this process, but the CSO may require that all transaction events, such as starting and stopping, are sent to his CSMS anyway.

The following steps are performed in this scenario:

1. Customer connects EV
2. Customer presses a "Start" button (physical or on display) to request charging.
   (This step is optional. Charging can also be requested implicitly by connecting the EV.)
3. Charging station sends an OCPP Authorize request to the local controller, which converts this into a call towards the POS system to signal a request to use the charger.

4. Cashier gives permission to start charging.
5. POS returns to local controller that permission is granted.
6. Local controller replies to charging station that authorization is accepted.
7. Charging station starts charging and notifies local controller.
8. Charging station sends periodic energy consumption updates to local controller.
   (These updates can optionally be transmitted to POS for display)
9. When customer stops charging, charging station notifies POS of end of transaction and consumed energy.
10. Optionally, the CSMS of the CSO can be informed of starting and stopping of a charge. (In this diagram it is performed after the transaction has ended, but it can also be done "live" during the transaction.)
11. Local controller sends total energy consumption to POS.
12. POS calculates price based on energy consumption and configured kWh price.
13. Customer pays at cashier.

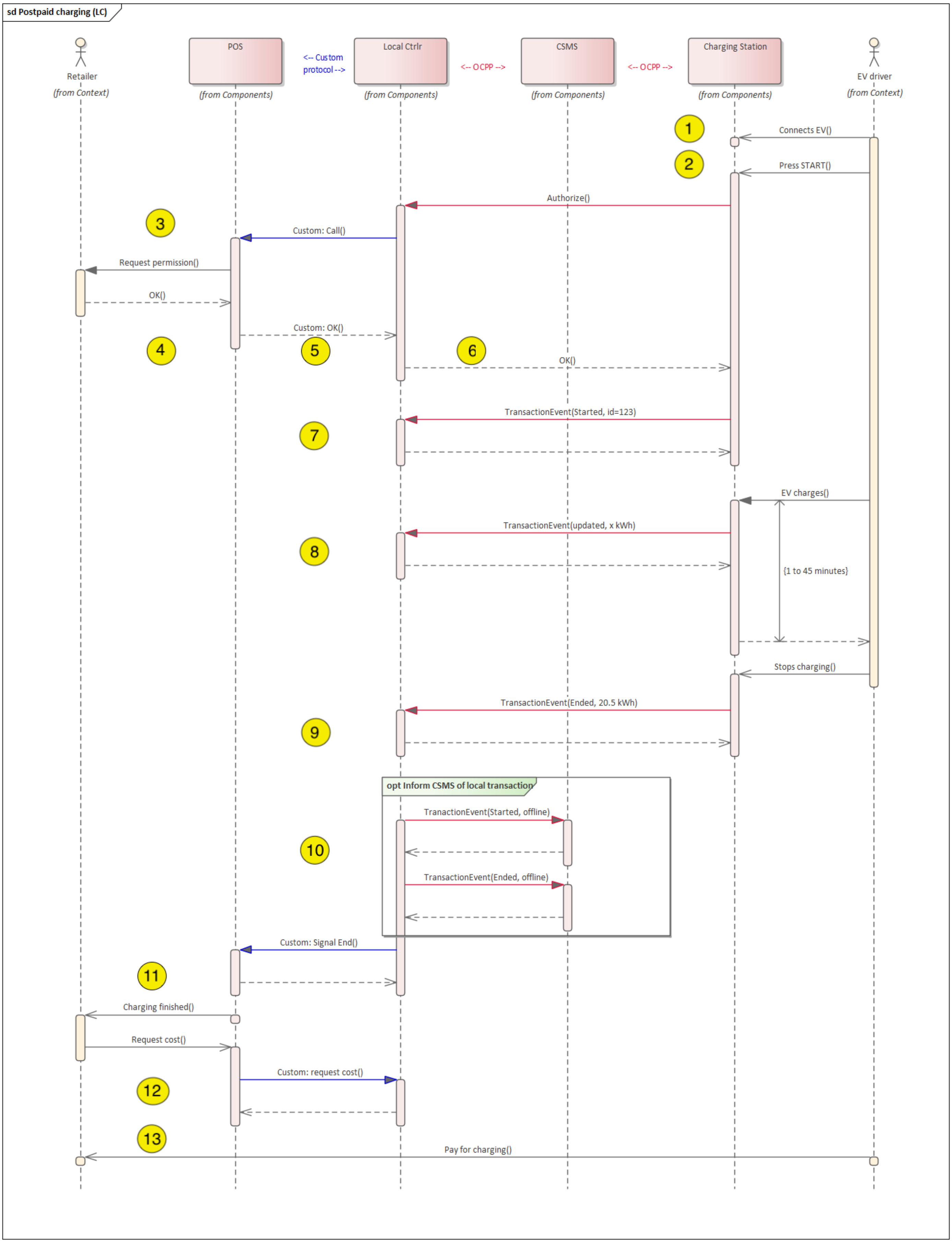


Figure 10. Paying in the shop after charging (LC)

When the integration with the charging station is implemented using a roaming protocol, such as OCPI, then the CSMS of the CSO plays a central role, because it controls the charging station on-site.

The following steps are performed in the scenario shown in Figure 11:

1. Customer connects EV
2. Customer presses a "Start" button (physical or on display) to request charging.
   (This step is optional. Charging can also be requested implicitly at connection of EV.)
3. Charging station sends an OCPP Authorize request to the CSMS, which converts this into an OCPI call for real-time authorization towards the POS system.
4. Cashier gives permission to start charging.
5. POS replies via OCPI to the CSMS that permission is granted.
6. CSMS replies to charging station that authorization is accepted.
7. Charging station starts charging and notifies CSMS.
8. Charging station sends periodic energy consumption updates to CSMS.
9. Optionally, the CSMS can forward these updates over OCPI to POS
10. When customer stops charging, charging station notifies CSMS of end of transaction and consumed energy.
11. CSMS sends total energy consumption to POS.
12. POS calculates price based on energy consumption and configured kWh price.
13. Customer pays at cashier.

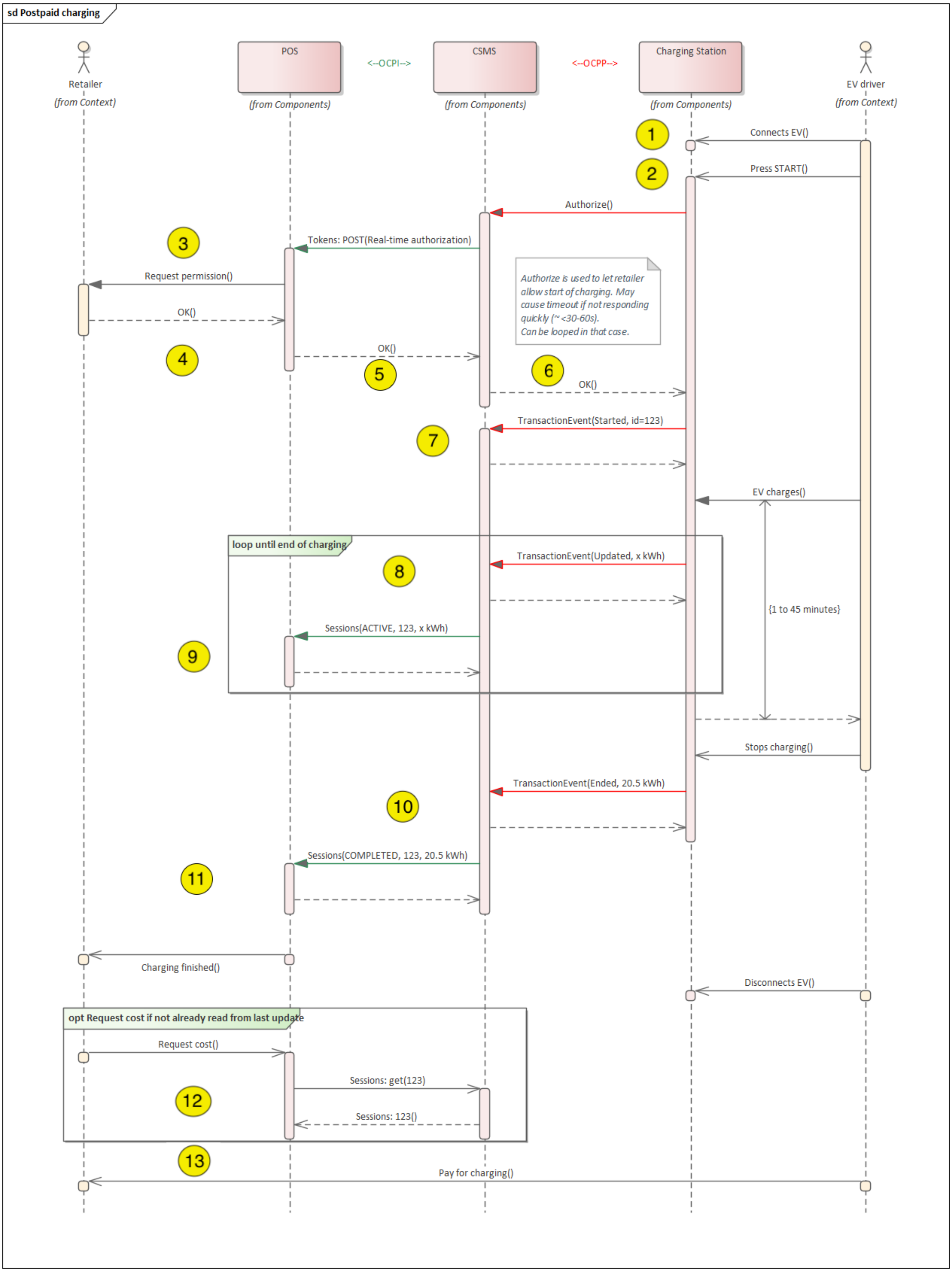


Figure 11. Paying in the shop after charging (OCPI)

5.3. Paying in the shop prior to charging (prepaid)

The flow of messages is very different for a prepaid payment. When the customer prepays to charge for a certain amount, then the charging is not initiated by connecting the vehicle. Instead, it is started by the cashier when the prepaid amount has been paid. The POS system converts the prepaid amount to a certain amount of kWh of energy that can be provided.

A caveat applies to this scenario. OCPI and OCPP have no provision to start a charging transaction for a limited amount of energy. The only way to stop at a specific limit, is to check the intermediate meter values that the charging station sends, and stop the transaction as soon as the prepaid amount has been reached. Since this will never be exact, the retailer will have to accept an overshoot.

NOTE	This can be avoided by using an OCPP customization, as described in Appendix A: Prepaid customization. Future versions (i.e. after OCPP 2.0.1) will contain standard support for prepaid amounts.

The following steps are performed in the scenario of Figure 12:

1. Customer pays a prepaid amount at the cashier.
2. Cashier instructs POS system to allow charging for the prepaid amount of energy.
3. POS system tells local controller to start charge for prepaid amount of energy.
4. Local controller sends a remote start command to charging station.
5. Charging station acknowledges receipt of the command.
6. Charging station starts charging as soon as EV is connected and notifies local controller.
7. Charging station sends periodic energy consumption updates to local controller.
   (These updates can optionally be transmitted to POS for display)
8. Local controller monitors consumed energy and sends a remote stop command to charging station when prepaid amount of energy is reached or exceeded.
   (Optionally, local controller can slow the charging when consumed energy is near the limit, so that it limits the overshoot.)
9. Charging station notifies POS of end of transaction and consumed energy.
10. Optionally, the CSMS of the CSO can be informed of starting and stopping of a charge.
11. Local controller sends total energy consumption to POS.

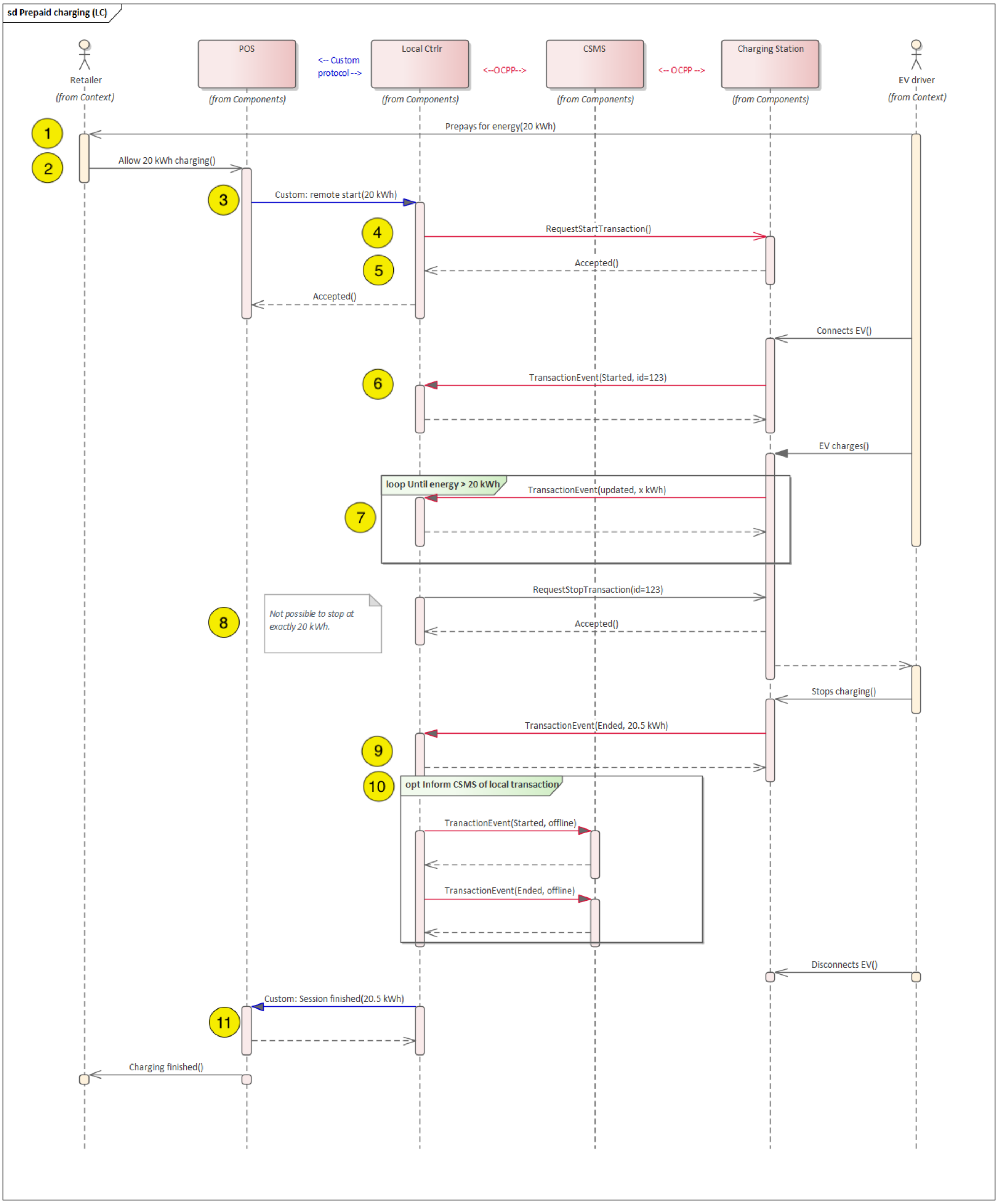


Figure 12. Paying in the shop prior to charging (LC)

If the charging stations are integrated via a roaming protocol, then the CSMS of the CSO notifies the POS sytem of consumed energy, and the POS has to stop the charging session when the prepaid amount has been reached. These steps may involve a bit more latency compared to a setup with a local controller. As a result the risk of overshooting the prepaid amount is larger.

The following steps are performed in the scenario of Figure 13:

1. Customer pays a prepaid amount at the cashier.
2. Cashier instructs POS system to allow charging for the prepaid amount of energy.
3. POS system requests CSMS of CSO to start a charging session.
   (There is no provision in OCPI to specify a maximumum amount of energy for a charging session.)
4. CSMS sends a remote start command to charging station.
5. Charging station acknowledges receipt of the command.
6. Charging station starts charging as soon as EV is connected and notifies CSMS.
7. Charging station sends periodic energy consumption updates to CSMS.
8. CSMS sends energy consumption updates to POS system.
9. POS system monitors consumed energy and sends a remote stop request to CSO when prepaid amount of energy is reached or exceeded.
   (In this case, CSMS cannot slow the charging when consumed energy is near the limit, because is it not aware of the prepaid energy amount.)
10. Charging station notifies CSMS of end of transaction and consumed energy.
11. CSMS sends total energy consumption to POS.

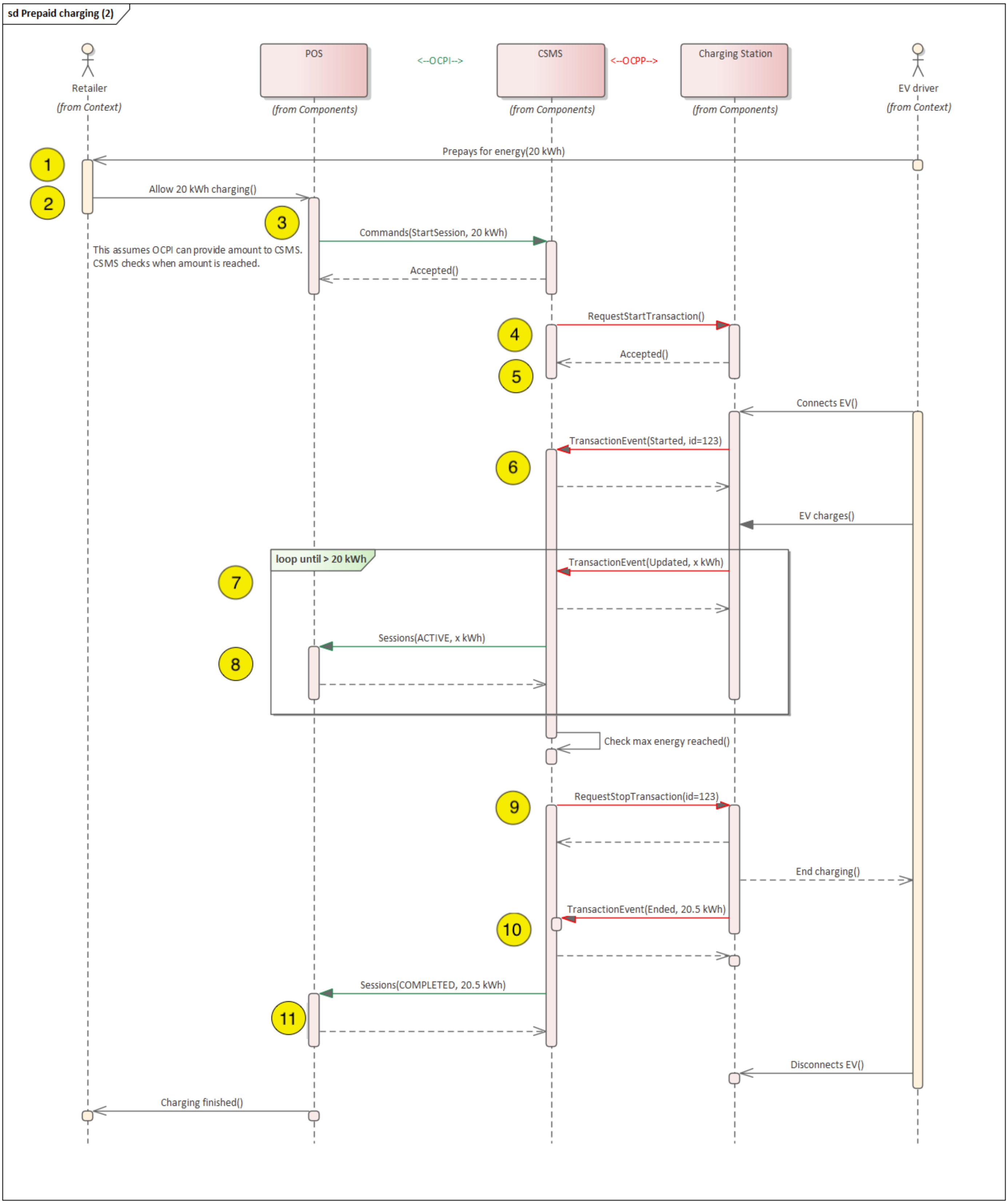


Figure 13. Paying in the shop prior to charging (OCPI)

5.4. Payment terminals

Initially most charging stations were only supporting EMSP charging cards as a payment method. Recently, Germany introduced legislation that mandates public charging stations to be equipped with a payment terminal as of July 1st, 2023. Similarly, the Alternative Fuels Infrastructure Regulation (AFIR) of the European Union, which is still under construction and debate at the time of writing, proposes to mandate direct payment support for charging stations with a power of 50 kW or more, as of January 1st, 2027.

The OCPP specification is about the communication between charging station and backend. It does not cover payment methods, because that is handled by the backend, or it involves communicating with other systems and other parties, like a payment terminal or a payment provider. Any identifier (up to 36 characters in length for OCPP 2.0.1) can be used to authorize a charging transaction. This means that credit card numbers, credit authorization references or other unique identifiers can be used as authorization tokens.

5.4.1. Electronic payment via EMSP smartphone app

This form of payment actually does not involve a payment terminal, but it is a common way to support direct payment at any charging station.

The EMSP provides a smartphone app that the customer can use to start a charging session. The customer needs to enter credit card details in the app, after which the app takes care of payment via a payment provider of the EMSP. (This is often called the "web shop model"). Via a roaming protocol the EMSP requests the CSO to remotely start a charging transaction on the charging station, using a unique identifier from the EMSP as authorization token.

The CSO and charging station are not involved in the payment by the user.

5.4.2. Integrated payment terminal

If no app is used, then electronic payment is possible via a credit card or payment terminal, that is located in the charging station. The credit card number or an authorization reference from the payment terminal is then used as an identifier that authorizes the charging.

The diagram in Figure 14 shows a message flow for a possible implementation of an integrated payment terminal in a charging station.

This implementation assumes that the payment terminal has not only a connection with a payment provider, but also a connection with the CSMS. It will send the credit card number that has been authorized by the payment provider, to CSMS as a valid identifier for a charging. The charging station will use the credit card number as part of an OCPP authorization request towards CSMS, which will then grant authorization. The payment terminal periodically polls the CSMS to check if the charge session has finished. If so, then CSMS returns the amount that the payment provider should capture from the credit card. The payment provider may have reserved a certain amount on the credit card, which will be released once the final amount is captured.

When a contactless card reader is used, then the same reader can read both standard RFID charge cards and credit cards (or other forms of electronic payment means). The fragment named "alt Type of card", shows the difference in handling a charge card or a credit card.

NOTE	This is only one of several ways to use a payment terminal in a charging station. It is shown for illustrative purposes only. The Open Charge Alliance has no opinion on which is the correct or best way to integrate a payment terminal.

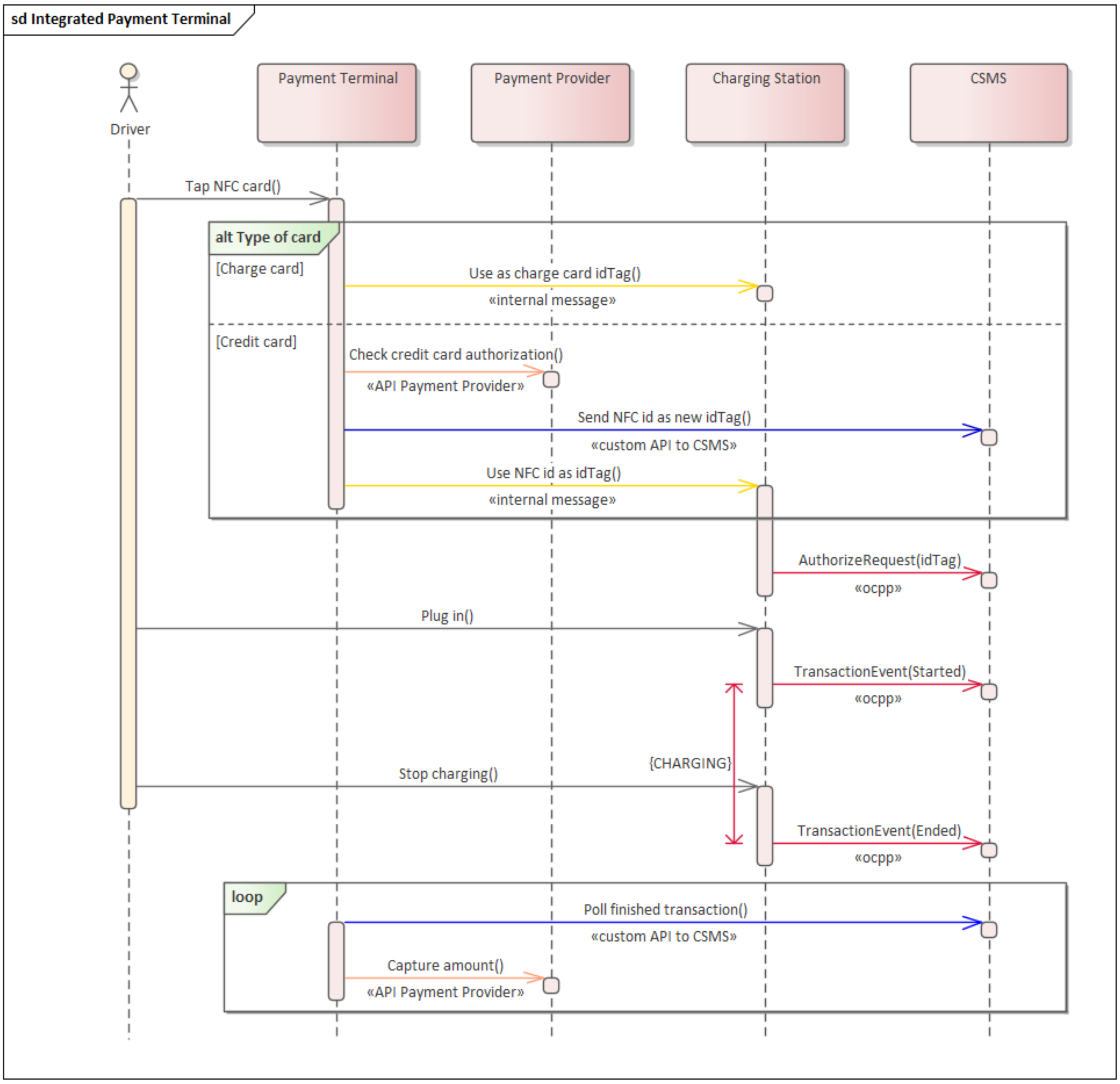


Figure 14. A charging station with an integrated payment terminal

Prepaid with integrated payment terminal

A charging station with an integrated payment terminal can be made to support a prepaid amount. The customer would have to enter the maximum amount in the user interface of the charging station. The station then calculates how much energy it can provide for this amount, and it will stop the transaction when that is reached.

The same mechanism could also be used when charging with an EMSP charge card, but that is not a typical scenario.

5.4.3. Outdoor payment terminal

Whereas the previous diagram assumes a payment terminal that is an integral part of the charging station, the next diagram, Figure 15, shows how an outdoor payment terminal can be used. An outdoor payment terminal is a central payment terminal at the forecourt that handles electronic payments for all fuel pumps and charging stations at the forecourt.

The main difference is, that the charging station cannot initiate the charging transaction itself, because the credit card reader is not located in the charging station, but in the outdoor payment terminal. The outdoor payment terminal therefore requests CSMS to remotely start a charging transaction at the specified charging station, by sending it the credit card number that has just been authorized by the payment provider. The remainder of the steps is identical to the process in Figure 14.

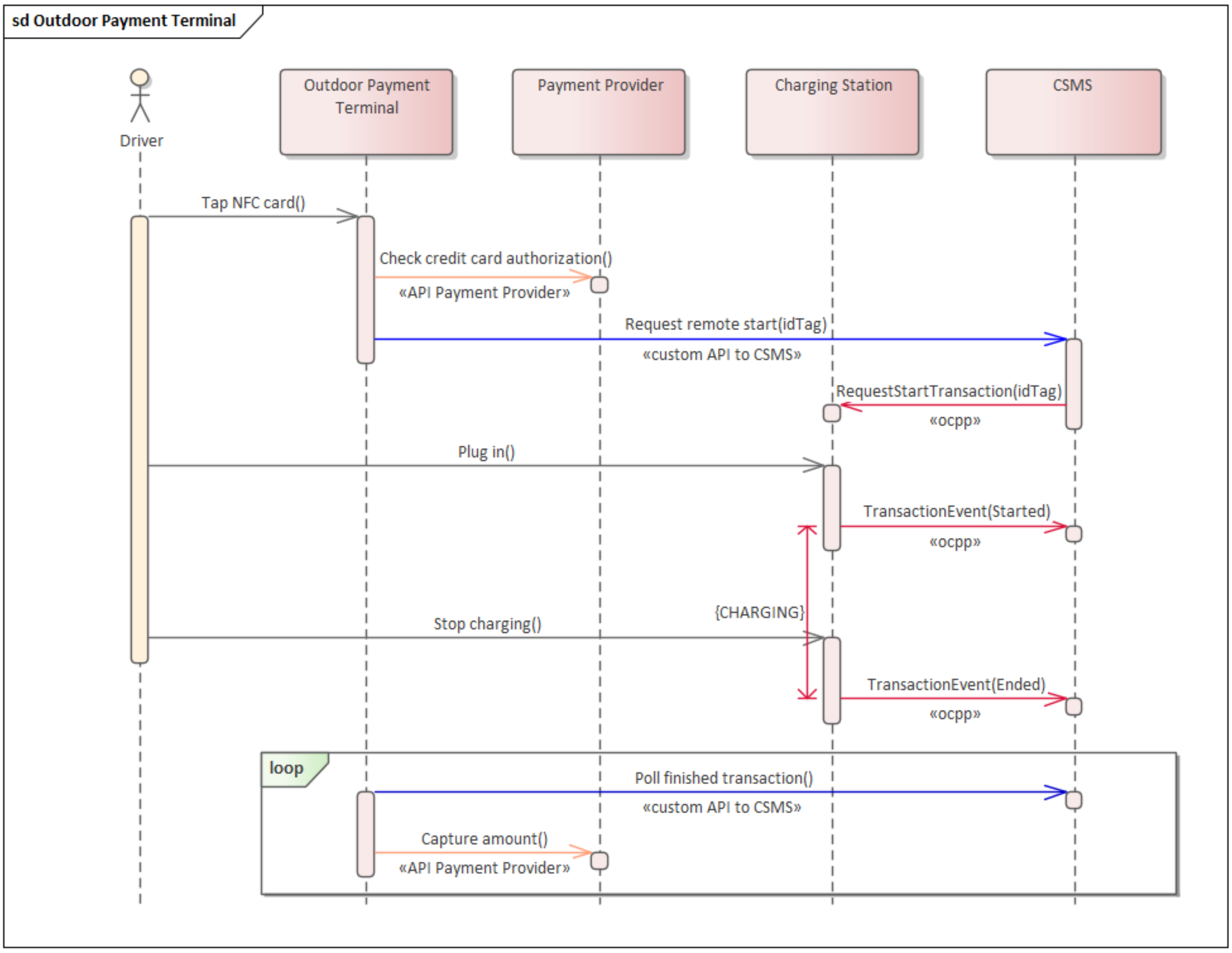


Figure 15. Using an outdoor payment terminal to start a charging session

5.4.4. Payment provider in EMSP role

A third approach that is worth mentioning, is similar to the above-mentioned method with one notable difference. It is not the payment terminal that communicates with the CSO, but the payment provider. The payment provider acts in the role of an EMSP and uses a roaming protocol to request the CSO to remotely start a charging session for the user. This requires the payment provider to have a roaming relationship with the CSO. It is very similar to Electronic payment via EMSP smartphone app.

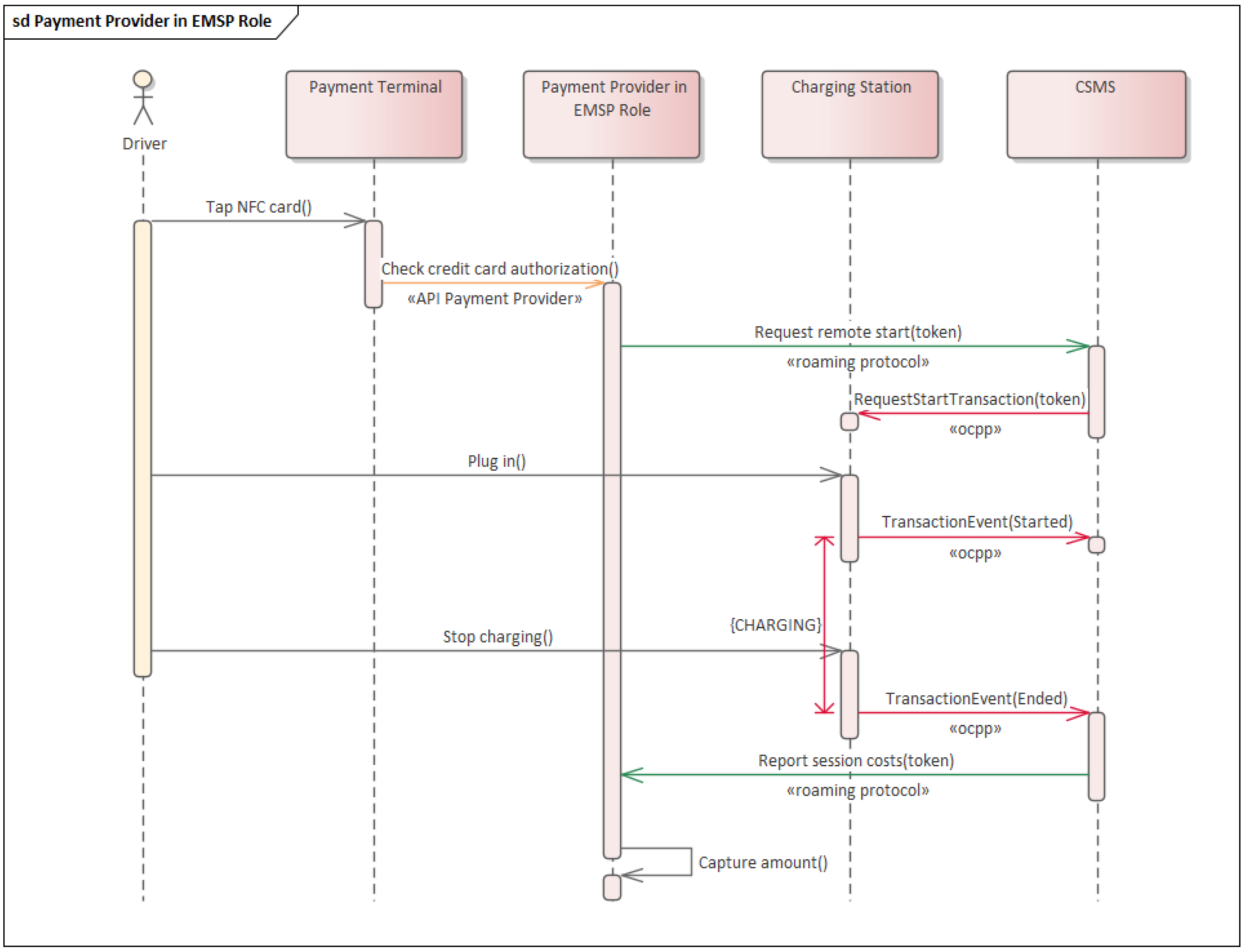


Figure 16. Payment provider acting in EMSP role

5.5. ISO 15118 Plug-and-Charge and AutoCharge

Two payment methods, that are specific to electric vehicle charging, are

- ISO 15118 Plug-and-Charge [3]
- AutoCharge [4]

When using one of these methods, the vehicle will automatically be authorized for charging, assuming that the associated charging contract is valid. The sequence of events is identical to charging with an EMSP charge card, as shown in Figure 8 and Figure 9, with the exception that the customer no longer has to present a charge card at the charging station, because the vehicle takes care of it.

In the case of AutoCharge, the vehicle's MAC address is associated with the EMSP charge card of the customer the first time the charge card is used in a specific charging station network. For subsequent charging sessions the charge card is then no longer needed, because the MAC address that the charging station reads upon plug-in of the cable, is sufficient to authorize the charging.

In the case of Plug-and-Charge, an EMSP charging contract has been installed into the vehicle at some point in time. (How this exactly works is out of scope for this paper. Suffice it to mention, that the ISO 15118 Plug-and-Charge system provides ways to update or replace the EMSP contract in the vehicle when needed.) When the vehicle plugs in into a Plug-and-Charge enabled charger, the EMSP charging contract is sent to the charger. This contract is then used to authorize the charging.

6. Displaying tariff and price

Fuel stations are required to show fuel prices at the pump. Such a requirement does not yet exist for charging stations in most countries, but it is likely to be mandated in the near future. Some countries are already introducing legislation that requires that the charging tariff is shown on a display prior to starting a charging session. This is often limited to the ad-hoc tariff, e.g. for direct payment at the payment terminal. This removes the complexity of having to get a user-specific tariff from an EMSP.

Since tariffs can potentially be quite complex with prices depending on things like time of day, power, amount of energy and type of contract, OCPP has adopted the approach of letting the CSMS calculate the cost and communicate this to the charging station. In a situation where CSO and EMSP are not the same party, we have to deal with two different prices: a wholesale price that CSO is using towards the EMSP and a retail price of EMSP to the customer. It is the retail price that should be communicated on the charging station. Note, that the EMSP retail price can vary from a simple surcharge on the wholesale price to something completely unrelated, like a flat rate.

Upon each meter value that the charging station sends, CSMS will send back the calculated running cost of the transaction, when OCPP 2.0.1 is used. This means that the running cost on the display will be updated after each meter interval. Typically, meter values are sent every 30 to 60 seconds on a fast charger (level 3) and every 5 to 15 minutes on a regular (level 2) charging station.

If a faster update frequency is required, then the cost calculation must be done locally on the charging station. This can be supported with a few custom messages in OCPP. This is explained in detail in the OCA application note: "OCPP & California Pricing Requirements", which can be downloaded from https://openchargealliance.org.

7. Appendix A: Prepaid customization

The versions of OCPP that are currently in use, 1.6 and 2.0.1, do not have a provision to automatically stop a charging session when a predetermined amount of energy has been charged. When doing prepaid charging, the CSMS or the POS would have to stop the charging session, based on meter readings that it receives from the charger. The frequency at which these reading are sent, is configurable, but even when sent every 10 or 30 seconds, it is impossible to stop exactly at a specific energy amount.

The only way to stop charging at an exact or nearly exact amount, is to let the charging station do this. In order to achieve this, the amount of energy that is allowed to be charged must be communicated to the charging station when the charging session starts. This means that the command by which the prepaid charging session is initiated, RequestStartTransaction, must be extended with a new parameter for the maximum energy amount. For OCPP 2.0.1 this can easily be achieved by adding this extra field to the CustomData part of the RequestStartTransaction message. It is not as simple for OCPP 1.6, which does not have support for extending messages. In that case a completely new message must be sent as part of a generic DataTransfer message.

7.1. Prepaid customization with local controller

The diagram in Figure 17 shows the sequence of messages when a local controller is used for integration at the forecourt. The only message that needs to have a custom field added for the requested prepaid amount of energy, is the RequestStartTransaction message. This is shown in bold in the diagram.

Now that the amount of energy to charge can be passed on to the charging station, it will be able to stop at exactly the right moment and there will be no overshoot. This, of course, assumes that the software in both CSMS and charging station supports the custom field.

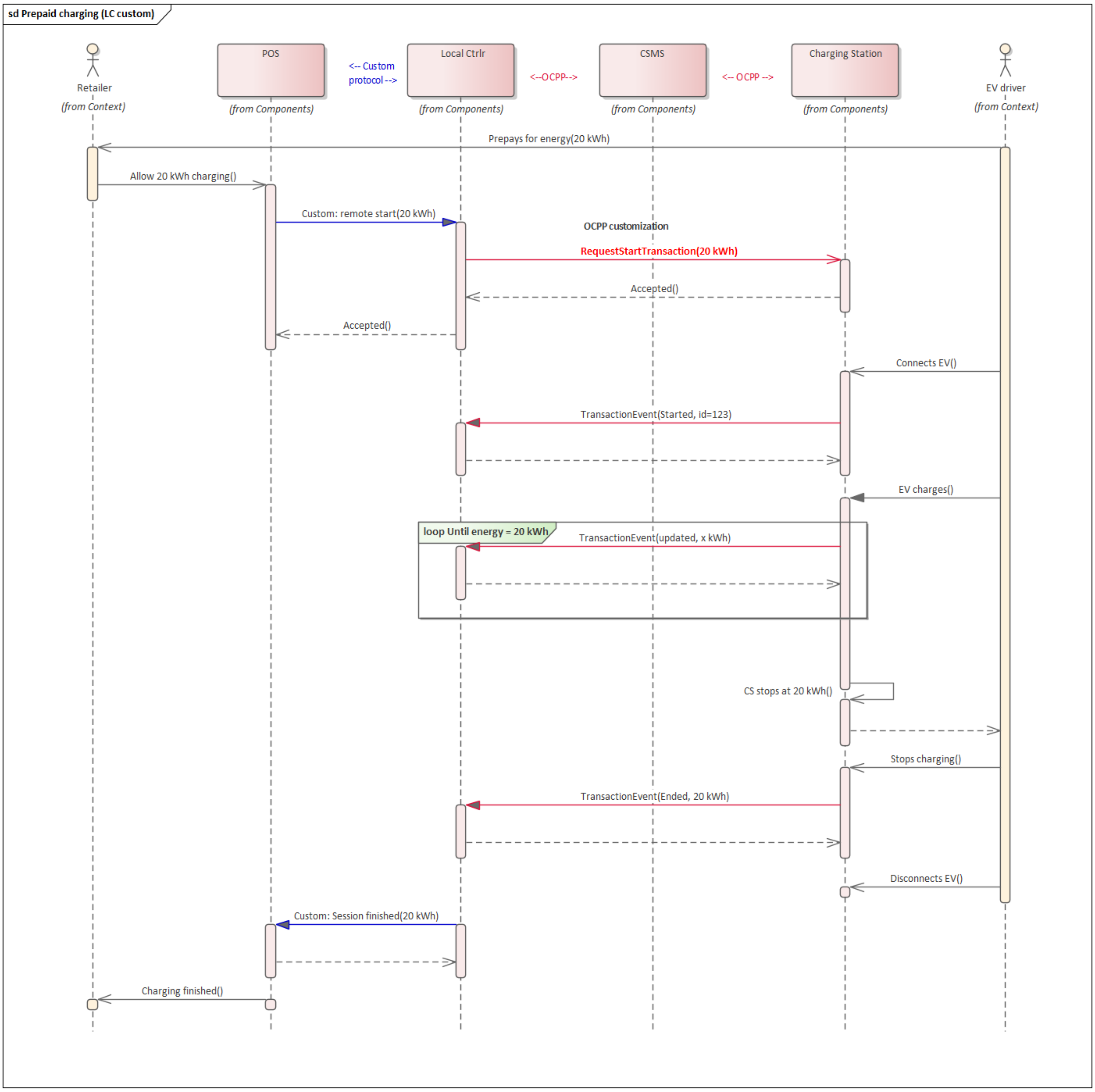


Figure 17. Prepaid charging customization with local controller

Below is an example of what a prepaid customization could look like. The element "customData", which is part of any message or type, can be extended with additional fields. The "vendorId" string identifies the type of extension that it contains as a unique reverse domain name.

Standard message to request a charging transaction

```
RequestStartTransaction {
   "evseId": 1,
   "remoteStartId": 12345,
   "idToken": "5220780935301234"
}
```

Extended message to request a charging transaction for at most 20 kWh

```
RequestStartTransaction {
   "evseId": 1,
   "remoteStartId": 12345,
   "idToken": "5220780935301234",
   "customData": {
       "vendorId": "com.example.prepaid-energy",
       "energyAmount": 20000
   }
}
```

For more information on how to customize an OCPP message, see the OCA Application Note "Customizing OCPP Implementations", which can be downloaded from https://openchargealliance.org.

7.2. Prepaid customization with a roaming protocol

If a roaming protocol, like OCPI, is used to integrate the charging station at the forecourt, then it depends on the capabilities of this protocol whether it supports a prepaid energy amount or can be extended to support it. This is beyond control of OCA.

8. Appendix B: Diagrams with OCPP 1.6 messages

The sequence in the diagrams om Typical payment scenarios for charging stations use OCPP 2.0.1 messages, but similar messages exist in OCPP 1.6.

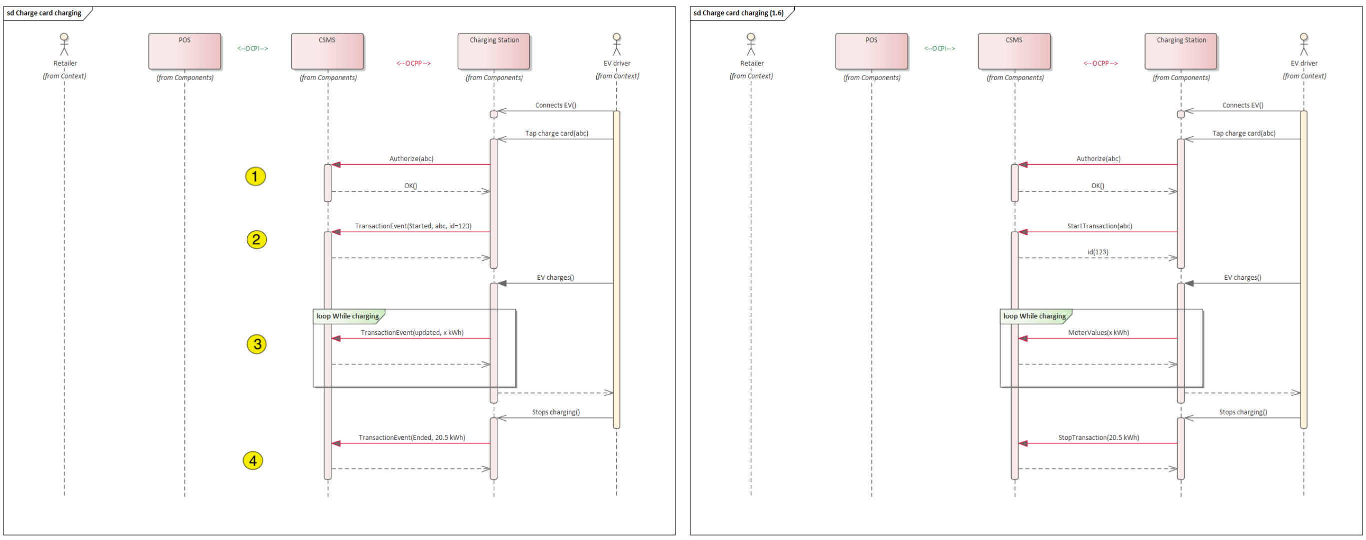
The following is a translation table that shows the corresponding OCPP 1.6 messages.

Table 1. OCPP 2.0.1 messages in diagrams and corresponding messages in OCPP 1.6

OCPP 2.0.1	OCPP 1.6
Authorize	Authorize
TransactionEvent(Started)	StartTransaction
TransactionEvent(Updated)	MeterValues
TransactionEvent(Ended)	StopTransaction
RequestStartTransaction	RemoteStartTransaction
RequestStopTransaction	RemoteStopTransaction

In order to demonstrate how straightforward the translation to OCPP 1.6 messages is, we show the diagram of Figure 9 and a diagram with OCPP 1.6 message names next to each other:

Diagram for charging using EMSP charge card shown for OCPP 2.0.1 and 1.6



9. Notes

[1] Fast charging is not normally done over 80%, since charging speed quickly drops above 80% state of charge.

[2] This can be avoided by using a local controller integration as described in Using an on-site local controller.

[3] See https://en.wikipedia.org/wiki/ISO_15118#Plug_&_Charge

[4] See https://github.com/openfastchargingalliance/openfastchargingalliance/blob/master/autocharge-final.pdf