Roaming Guidelines for EV Charging

Electric Vehicle Infrastructure Development Project **EVID-2005**

Public Report: Project Overview and Results (V 1.0)

Prepared by: BC Institute of Technology,

Smart Microgrid Applied Research Team and AES Engineering

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Introduction and Overview

This Project de-risked and validated novel solutions for electric vehicle (EV) charging, and demonstrated how the solutions can be applied to address key barriers to EV adoption. The Project specifically focused on Electric Vehicle Energy Management Systems (EVEMS), and open protocols for:

- command and control of charging stations
- demand response (DR)
- roaming
- payment.

This report is focuses on EV charging guidelines for roaming.

Background

What is Roaming?

EV roaming is somewhat similar to cellular (cell) phone roaming. Cell phone carriers have contracts with other cell phone carriers so that users can use their cell phone with other carriers when a carrier doesn't cover a particular geographical area.

With EV roaming, drivers might have an account with one Charge Station Network Management System (CSNMS) provider but want to charge at an EV charger managed by a different provider. As long as both CSNMS providers are willing to share customer account info so they can track who to charge for charging, then drivers can use either set of chargers without having to have accounts with both CSNMS providers.

EV charging payment differs from filling up at a gas station in that gas stations don't require drivers to have accounts with them. Gas stations are generally staffed, and take payment by credit card, cash, or contactless payment.

Why is Roaming Important?

Roaming is important to EV drivers because there are many CSNMS providers in the marketplace, each with their own account requirements. When travelling internationally, there will be more CSNMS providers, with their unique account requirements. Many CSNMS providers use radio frequency identification (RFID) cards or fobs that EV drivers use to swipe on a EVSE's RFID reader in order to start a charge. With so many different CSNMS providers, EV drivers often have a large collection of these cards and fobs to manage, and have to manage the account balances associated with each provider.

EV roaming is the result of cooperation of CSNMS providers to manage payment 'behind the scenes' in order to provide a higher level of convenience for EV drivers. With roaming, theoretically at least, drivers only need one account/RFID card/fob with their preferred CSNMS provider, and those providers would have contracts with other providers to allow drivers to use a different providers' chargers.

Additionally, there is no need to remember the balances on multiple accounts. EV drivers can have one account, one balance, and ability to charge with many different providers.

How Does Roaming Work?

Roaming works by CSNMS providers forming agreements to share information with each other about customers, chargers, charger locations, and charging sessions. Providers can share customer IDs and RFID info so that when a roaming customer requests a charge at an EV charger, the provider can recognize the driver, the provider they are associated with, approve them to start a charge, then bill the account associated with the customer's provider so the provider that supplied the charge is compensated.

Depending on the agreements between the CSNMS providers, there may be roaming fees associated with this roaming service.

Open Charge Point Interface

In this current project, and several past projects, BCIT has demonstrated commitment to using open, non-proprietary, standard approaches to communications related to EV charging, energy management, and smart grid technologies in general. For this project, BCIT selected the Open Charge Point Interface (OCPI) protocol to implement roaming.

OCPI is a free, global, open communication protocol used worldwide to facilitate roaming between eMobility service providers. In many jurisdiction, independent, open roaming protocols such as OCPI are mandated. OCPI is managed and supported by the EVRoaming Foundation – www.evroaming.org – whose ultimate goal is to allow any EV driver to charge at any charging station.

How OCPI Works

There are two main market roles that are of concern in OCPI:

- CPO – Charge Point Operator. This is an entity that operates a network of one or more Charge Points. A Charge Point is a local collection of EV chargers, often referred to as Electric Vehicle Supply Equipment (EVSE).
- eMSP – e-Mobility Service Provider. This is an entity that provides EV drivers access to charging services.

Quite often the CPO and eMSP are one and the same entity, with different business departments handling the different roles.

OCPI allows many different Communication Topologies that are combinations of two main types:

- Peer-to-peer – One role talking directly to another, generally CPO to eMSP and vise versa.
- Hub – A specialized role that allows many market roles to many other market roles without needing a dedicated peer-to-peer connection.

This allows for many different combinations:

- Straight peer-to-peer – One CPO and one eMSP talking to each other.
- Multiple peer-to-peer connections – Many CPOs and many eMSPs talking directly to each other. Not every CPO needs to talk to every eMSP (and vice versa).

- Peer-to-peer roles – A platform of CPOs talking to another platform of eMSPs only needs one platform-to-platform (peer-to-peer) connection to connect all the CPOs to all the eMSPs.
- Peer-to-peer mixed roles – Many platforms support multiple CPO and eMPS roles. A single platform-to-platform OCPI connection allows all the roles in one platform to talk to all the roles in the other platform.
- Multiple peer-to-peer – Allows multiple platforms (with many roles) to talk to multiple other platform roles with only connections between platforms and directly role-to-role.
- Platforms via Hub – All platforms talk directly to a single Hub, which then re-routes messages to specific platforms/roles. Every platform just needs one connection into the Hub to be able to talk to all other platforms.
- Mixed Hub and direct peer-to-peer – Most communications go through the Hub but there may be some special cases that require direct peer-to-peer communication.

Every entity, regardless of what their roles may be, is identified based on a Country Code and a Party ID. The Country Code follows the ISO-3166 alpha-2 country code standard where every country in the world has an assigned, unique two-letter code, e.g. CA for Canada and US for United States of America. The Party ID follows the ISO-15118 standard and is a unique (within a single country at least) 3-letter code.

OCPI has a very strictly defined Charging Topology:

- A *connector* is a specific socket or cable that Electric Vehicles (EVs) use to charge through.
- An *EVSE* is the device that controls the power being supplied to a single EV in a single charging session. Despite having multiple connectors, only one connector on an EVSE can be active at the same time. Multiple EVSEs in the same housing can give the appearance of multiple active connectors in a single EVSE, but this is not how OCPI describes things.
- A *Location* is a collection of one or more (usually many) EVSEs in the same local area.

OCPI is a communication standard. It defines only what messages are passed between peers. It does not define how the message passing should be implemented. The OCPI protocol is based on HTTP (Hypertext Transfer Protocol) with security provided through SSL (Secure Sockets Layer) and token-based authentication. OCPI uses JSON (JavaScript Object Notation) format for messages and follows a RESTful (Representational State Transfer) architecture for web services.

OCPI supports two models for transferring data:

- Pull – The receiver requests a list of objects every so often. How often will depend on what is needed and how likely it is to change. Using Pull means there's a chance that information could be out-of-date until the next Pull request. OCPI requires that the Pull model always be implemented.
- Push – Object changes are sent directly to receivers whenever there's a change to the object. This way information is kept up-to-date and synchronized almost immediately. The Push model is not required for an OCPI implementation, although strongly recommended.

OCPI uses some of the HTTP request methods as are standard in REST APIs (Application Programming Interface):

- GET – Used to request information, e.g. the Pull method.
- PUT – Creating new information and updating existing information, e.g. the Push method.
- PATCH – Partially updating existing information, for small changes.
- DELETE – Removing existing information, e.g. deleting customer information.
- POST – A request to *do* something, e.g. send a command to an EVSE.

Every message sent expects to receive a status message back:

- 1xxx – Success. The message was received and successfully completed.
- 2xxx – Client error. The receiver was unable to process the message sent.
- 3xxx – Server error. The message was successfully received but the server encountered an error attempting to process it.
- 4xxx – Hub error. The Hub was unable to properly route a message.

OCPI defines numerous modules to be defined. Some modules are not required for some roles and may therefore be ignored.

- Versions – Versions is a mandatory module. Clients learn which versions of OCPI are supported and which modules are supported for each of the versions.
- Credentials – Credentials is a mandatory module. The Credentials module is used to exchange credentials tokens that are to be used by both parties for authorizing requests.
- Locations – Describes the charging locations of a CPO. This includes the EVSEs at the location as well as the connectors for each of the EVSEs.
- Tariffs – Defines how charges are to be applied during a charging session. Charging costs can be based on time spent charging, energy consumed while charging, and time spent parked after the charging has completed.
- Tokens – Tokens are customer references, often just the RFID of an assigned RFID card or fob that uniquely identifies the customer.
- Sessions – The description of a single charging session.
- CDRs – A Charge Detail Record is the description of a concluded charging session. It is used exclusively for billing. Because of this, once a CDR is created it cannot be changed. Instead a Credit CDR is created to adjust the initial CDR. Information contained in the CDR is as it was at the start of the charging session. This preserves against name and location changes.
- Commands – Allows commands to be sent remotely to an EVSE. The commands supported are:
    - START_SESSION – Start a new charging session for a customer (Token).
    - STOP_SESSION – Finish up a charging session for a customer.
    - RESERVE_NOW – Make a reservation for a customer at a specific Location or EVSE.
    - CANCEL_RESERVATION – Cancel an existing reservation for a customer.
    - UNLOCK_CONNECTOR – Remotely unlock a connector/EVSE.
- ChargingProfiles – Allows the EV driver to query and to set the desired parameters for the charging session, e.g. charging speed. These are recommendations to the EVSE and many other factors may limit how close the charging session will come to what is desired.
- HubClientInfo – Allows CPOs and eMSPs to communicate with a Hub and find out what other CPOs and eMSPs are available through the Hub.

Other Roaming Technologies

ROEV

In 2015, BMW of North America, Nissan, CarCharging/Blink, ChargePoint, and NRG EVgo announced the ROEV Association as a neutral collaboration designed to enhance EV adoption by providing public charging interoperability. Unfortunately, by 2018 ROEV failed to come to fruition. The National Electrical Manufacturer's Association (NEMA) had managed to produce an RFID standard for EV charging but other standards required failed to gain consensus and so ROEV was unable to get off the ground.

https://eepower.com/news/roev-founded-to-make-ev-charging-more-accessible/
https://electricrevs.com/2018/03/30/what-happened-to-roev/

Open Clearing House Protocol (OCHP)

OCHP is a product of Smartlab Innovationsgesellschaft GmbHt and ElaadNL that handles integration via Hubs. OCHP is used by the roaming hub e-clearing.net operated by Smartlab and owned by Smartlab and ElaadNL. To handle peer-to-peer, OCHPDirect is needed. The latest version of OCHP is v1.4 (2016) and OCHPDirect v0.2.6 (also 2016). V1.5 has been announced (2020) but not yet released. OCHP is based on the SOAP (Simple Object Access Protocol) protocol and largely relies on asynchronous communication to avoid the risks of a single point of failure. Currently, e-clearing.net only requires a fee to join the platform.

http://www.ochp.eu/
https://solidstudio.io/blog/ev-roaming-with-open-standards-ocpi-ochp

Open InterChange Protocol (OICP)

OICP was created in 2012 by Hubject, a German (Berlin) EV charging clearinghouse. The most recent version, 2.3, was released at the end of 2021. Predominately used in Europe by 1000 companies in 43 countries, OICP is planning to expand into the US market. OICP is proprietary, not open-source like OCPI. OICP acts like a Hub to all the other connected CPOs and eMSPs. Integration just needs to be done with the Hubject platform to easily allow and alliance with other partners that also use OICP.

https://github.com/hubject/oicp
https://solidstudio.io/blog/oicp-ocpi-protocols

Demonstration

In order to test and confirm BCIT's Roaming implementation, the EVID software was installed and configured at two locations:

- Energy OASIS
- Riverbend Housing Co-operative

Each of these is described in more detail below.

Energy OASIS

OASIS is an acronym for Open Access to Sustainable Intermittent Sources. The Energy OASIS microgrid facility is an NRCan-funded project that was completed in 2014 on BCIT's main Burnaby campus. Energy

OASIS includes 250 kW of solar panels on two large parking canopies, a 500 kWh lithium-ion battery energy storage system (BESS), an advanced energy management system, and the main loads are two DCFC stations, and ten Level 2 EVSEs.

As part of the current project, and a previous NRCan-funded EVID project, BCIT created a Charging Station Network Management System (CSNMS) that uses the Open Charge Point Protocol (OCPP) to command and control EV chargers. BCIT was able to successfully demonstrate the ability to control the two DCFC units, and the collection of ten Level 2 EVSEs using this CSNMS. BCIT's CSNMS software also has EVEMS capability, and we were able to successfully demonstrate the ability to manage the load of up to ten concurrently charging EVs. This was critical as the electrical feed for the Level 2 chargers was only sufficient for 6 dedicated circuit EVSEs, so an EVEMS was necessary to manage these loads.

Riverbend Co-op

Riverbend Housing Co-operative is located at 1050 Quayside Drive in New Westminster, BC. It consists of 72 housing units, and a parking garage with 96 stalls including visitor parking. BCIT contracted AES Engineering to develop an electrical engineering plan to electrify 100% of the parking stalls in the parking garage. The project funded upgrades to the electrical infrastructure to allow for future growth. BCIT contracted PowerPros Electrical to undertake these upgrades under guidance of AES Engineering. The six Level 2 EVSEs are from project partner Sun Country Highway. The Sun Country Highway EVSEs are monitored and controlled by BCIT's CSNMS software, which uses a load management with monitoring strategy, with monitoring at the electrical panel. So while the individual EVSE circuits are dedicated, the system as a whole is still energy managed. The system is OCPP compliant, and additional chargers can easily be added to the system.

Testing

On Feb. 1, 2022, Roaming was tested with a Nissan Leaf as the test vehicle. The owner created a Carbon Plunk (formerly Sun Country Highways) account (https://i.carbonplunk.com) and was able to successfully use the Carbon plunk EVportal to find an available EVSE at OASIS, start a charge, monitor the progress of the charging session, and stop the charging session. BCIT was able to remotely monitor what was happening via the Admin portal and verify what was happening every step of the way. After the charging session concluded, a CDR was generated from the charging session and sent to Carbon Plunk requesting that Carbon Plunk charge their customer and send the proper amount of money to OASIS. Both databases were checked to make sure that charging session tables were properly updated and reflected the charging that happened.

Recommendations

Upon reviewing the various existing EV Roaming standards that have been proposed, BCIT chose to go with OCPI as it is the most current and most supported Roaming standard. Its adoption throughout much of Europe suggests that it is robust enough to support many roles (CPO, eMSP, etc.) across many countries and therefore should do well in North America with its many provinces, and states.

OCPI released version 2.2.1 (minor improvements to 2.2) at the end of 2021 and is currently working on version 3.0 with the EVRoaming Foundation (https://evroaming.org/) which they hope to have completed by 2023.

BCIT has implemented OCPI 2.2.1 and has it freely available for download at:
http://files.mgrid-bcit.ca/download/

This is a full implementation of OCPP, OCPI, and BCIT's EVEMS software. It is easily customizable for anyone wanting to get implement Roaming with OCPI.

Conclusions

The Project results have helped to de-risk and validate using the OCPI standard to allow EV Roaming, allowing EV drivers to choose where and when they charge their vehicles without requiring a multitude of RFID cards and fobs and managing a multitude of account balances. This opens up many more charging options for drivers and encourages more people to adopt electric vehicles. Which brings British Columbia closer to the goal of no more internal combustion engine vehicles being sold after 2040. Roaming will also allow eMSPs access to far more customers once all eMSPs are able to share their customers with each other.

BCIT successfully developed and demonstrated open source software using the OCPI standard to allow EV Roaming between separate eMSPs. The open source software is available for download for any and all EV charging network operators to use.