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Cluster management system for electric vehicle supply equipment

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Abstract: **With the enhancement in the auto industry, Electric vehicles are now becoming a part of daily life. However, the major factor affecting its development is the lack of implementation for EV charging infrastructure i.e charging between EV and Electric vehicle supply equipment and also communication between EVSE and Central Management System. The two major types of charging infrastructures include Public and Private. This paper mainly focuses on the public charging infrastructure. The next step i.e communication between EVSE and CMS includes developing a mobile application that includes the open APIs to uptick usage of EVs. This paper also focuses on promoting vendor independent services to the customers.**

Keywords* — *EV, EVSE, CMS, Mobile application, OCPP

I. INTRODUCTION

Electric vehicles are the first to disrupt the transport markets as they can change the way power is generated, used, and directed. Electric vehicles are at risk of rapid growth in both the developed and developing economies as domestic fire engines dominate the transport sector. That is why the widespread acquisition of electric vehicles can bring about significant technological change in society using personal transport and the large-scale adoption of EVs.[9] The development of Electric vehicles faces the following major challenges infrastructure for electric vehicles, charging time, service of electric vehicles, and no assured government policy. The demand for charging infrastructure of electric vehicles is more important as the EVs on the road multiply. Out of these the major factors affecting the growth of Electric Vehicles in India are the lack of implementation standards for charging electric vehicles and communication between the Electric Vehicle Supply Equipment (EVSE) and the Central Management System (CMS).[4] Electric vehicle charging infrastructure can be classified as shown in the fig (1).

This paper focuses on the Fixed charging station infrastructure, including private and public charging stations. Most FCSs are slow chargers at homes and workplaces, often referred to as private charging stations (PrCS). For long-distance travel, the available charging station may not meet the requirement to ensure the ability to complete the round trip home.[10] In addition, if charging infrastructure is available at work, less expensive cars must meet the needs of the consumer. In metro cities, families living in societies or apartment complexes will face a challenge of charging at their homes due to common meter connection of basements or ground floors with other neighbours but all these are transitional challenges, and adoption of electric vehicles is inevitable, only proper policy and decision making will make it in a faster way.

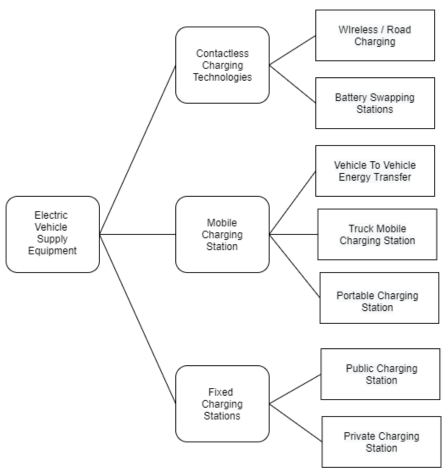

Figure 1:Classification of charging methods

One solution for this can be providing service for multiple vehicles at the same time with a given infrastructure. Current EV charging systems include charging networks limited to vendors. These EV charging networks focus on providing limited EV chargers to the provider. Wise use of independent EV chargers for providers has never been emphasized in these networks. The aim is to create opportunities to improve EVSE infrastructure and to provide EVSE-CMS communication to develop a

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cooperative charging system with vendor freedom. This paper gives a summary of this smart charging system intending toward its unique features and functionalities. The idea begins by thoroughly describing the central system and its basic requirements for the system to function. Then it describes the EV chargers, how it works, how it connects to the central system and focuses on details of the central system in more depth.

II. LITERATURE SURVEY

EV charging infrastructure commonly referred to as Electric Vehicle Supply Equipment (EVSE), is a key factor for a healthy EV ecosystem and requires adequate planning and electrical infrastructure dedicated to various levels of the distribution grid. This includes behind-the-meter customer-owned infrastructure. In the simplest way EV charging stations are set of electrical power, usually mounted on a wall or foot, providing safe control of power from the grid on car batteries. It is important to facilitate the adoption of temporary and long-term electric vehicles and the continued development of the automotive sector and therefore the availability of charging infrastructure is one of the keys to addressing various concerns.

A. *Types of charging methods*

Different types of chargers provide different levels of current and power as required to meet the specific battery requirements of a particular vehicle [11]. EV chargers range from as low as 500 watts (W) to up to 500 kW. It is expected that battery improvement, chemistry will make the charging much higher levels in the future. There are different charging methods currently used in India and globally namely Slow AC charging, Moderate AC charging, DC fast charging. This paper focuses on the public AC charging methodology. AC charging stations with power up to 7 kW per charging port are common in retail spaces, restaurants, and workplaces. These typically experience higher daytime and evening use. Most vehicles are equipped with an onboard charging system that converts grid-supplied AC power to the DC power required to charge the battery. Onboard chargers enable a vehicle to be charged directly from a standard home plug (slow AC) or a specialized AC charger (moderate AC) at home, workplace, or public location. Chargers that provide direct current to the vehicle battery and bypass the onboard converter are referred to as DC chargers or DC fast chargers due to their ability to provide higher charging rates. Charging equipment typically has some degree of intelligence that takes care of user authentication, vehicle communication, data collection and monitoring, and payment [7]. Fig (2) represents the publicly accessible fast chargers by each country.

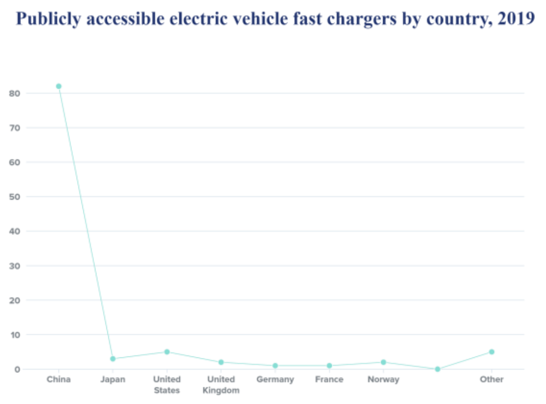

Figure 2: Country wise publicly accessible electric vehicle fast chargers

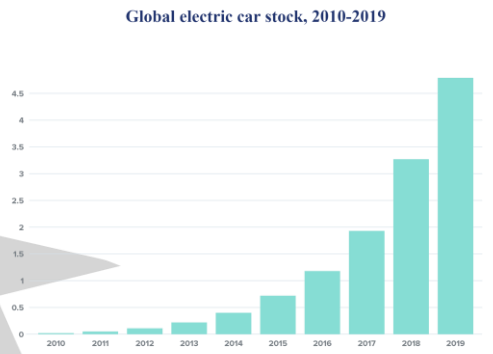

Figure 3: Global electric car stock

B. *Global Landscape*

Numerous studies around the world show one common problem with electric vehicles (EVs): drivers are afraid of not finding the right charging station when needed [5]. Globally, the increasing demand for EVs has created a significant need for more charging points [7]. About 7.3 million chargers are active worldwide (since 2019), with about 6.5 million private chargers, 0.6 million public chargers, and 0.26 million public chargers. China accounts for about 37%, 50%, and 81% of global chargers are private, slow, and fast public, respectively [7]. Fig (3) shows the global electric car stock. In most global EV markets, home and work charging is preferred over public charging stations [11]. Currently, more than 70% of charging is done at home. The publisher believes that over the next five years, the 70% home charge rate will drop to 50 to 60% while the workplace and public charging will increase. By 2019, there were about 7 million chargers worldwide, about 6 million were private chargers, simple car services at home, in residential buildings, and the workplace. Publicly available chargers account for 12% of global light chargers by 2019, most of which are slow chargers. Globally, the number of publicly available (slow and fast) chargers has increased by 60% in 2019 compared to the previous year, higher than the stock growth of electric car lights. China continues to lead in the release of publicly accessible chargers, especially fast chargers, suitable for its densely populated urban areas with little chance of private charging at home. Looking across the top seven EV regions it is apparent that medium-speed charging is by far the most common form of charging and will likely continue to be for the foreseeable future [11]. The chart below shows the distribution of chargers (medium, accelerated, fast) for the

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top seven EV countries globally. Here we see that medium AC charging represents between 50 to 90% of deployed chargers while DC fast chargers are below 20% of deployment in all countries but China [12], [13].

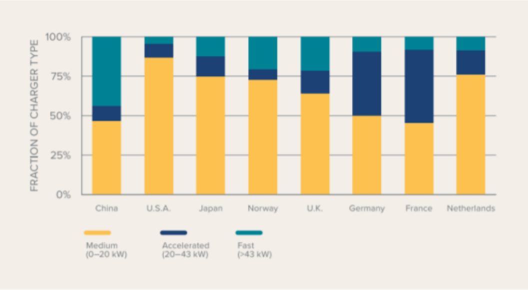

Figure 4: Distribution of chargers for the top seven EV countries

At the national level, the most charging infrastructure providers include TATA Power, CHARZER, Delta Electronics India, Fortum India, Mass-Tech, Exicom, Bright Blu, ABB India, Panasonic, and Ensto. TATA charging solutions meet a variety of definitions and standards and can be used for a variety of EV processing, models, and categories that offer the option of charging with its Mobile App Tata Power. Mahindra's NEMO Life app is based on NEMO, a cloud-based platform that enables shared and connected services to improve urban mobility. NEMO Life can be used to handle multiple vehicles, limiting these applications to that particular vendor.

III. COMMUNICATION INFRASTRUCTURE

The communication system incorporates the following actors: Electric Vehicle, Electric vehicle user, charger, central management system. This section provides details about each of the all building blocks.

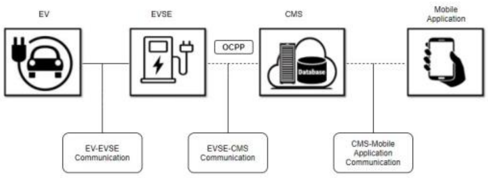

Figure 5: EVSE - CMS communication

A. *EV- EVSE Communication*

In EV-EVSE communication, an electric vehicle is connected to EVSE i.e.charger via powerline connection. Initially, protocol recognizes battery and charger followed by monitoring parameters of battery and charger management system like the voltage, temperature. This process is taken care of by EVSE itself. For other modes i.e. DC fast charging mode, international standards are available for communication between charge point and vehicle. These are examined, weighed up and the criteria for ranking are discussed below. The communication between EV-EVSE follows a certain algorithm and sequence to attain the goal of charging the vehicle. International standards help to assure that the system is safe, reliable, and interoperable too. IEC 61851-23 defines requirements for DC charging infrastructure. Details of these systems are based on the physical layer, application layer, and voltage range. IEC 61851-24 is standard for digital communication between a DC charging infrastructure and the EV, for the control of DC charging.

B. *EVSE – CMS communication*

The charge point needs to communicate with CMS for authorization and authentication of the user before the electric vehicle starts or stops charging. It needs to update the CMS with details like firmware version, vendor performance, model number, details regarding charging sessions, give periodic heartbeat, error conditions in EVSE, charging metering values for respective sessions. These meter values and timestamps are helpful for the Time-of-Day metering. CMS will contact EVSE for details at firmware update and for procuring the meter values to provide extra information about meter values. CMS can request EVSE for booking and cancellation based on requests from EV users. EVSE-CMS communication policy is to improve an interactive system for charging points with vendor independence. OCPP is a standard open charge point protocol for communication between EVSE and CMS.

OCPP 1.6 provides 25 operations for the EVSE – CMS communication with 10 operations initiated from EVSE and 15 operations initiated from CMS [1]. Following are the details of the EVSE and CMS initiated operations and their description respectively.

Sr. No.	Operations	Description
1.	Authorization	To authorize user before the charging station starts
2.	Boot Notification	To inform central system about the charge box configuration details
3.	Data Transfer	To send vendor specific information to central system
4.	Diagnostics Status Notification	To inform about the completion of diagnostics file upload to central system
5.	Firmware Status Notification	To inform about progress of firmware update
6.	Heartbeat	To inform the central system at particular interval that the charger box that is still alive
7.	Meter Values	To provide information about meter values to central system at some defined interval
8.	Status Notification	To notify about a status or error condition to central system
9.	Start Transaction	To inform the start of a charging transaction
10.	Stop Transaction	To inform the stop of a charging transaction

Figure 6: Operations Initiated by EVSE

Sr. No.	Operations	Description
1.	Cancel Reservation	To cancel a reservation based on the reservation ID
2.	Change Availability	To request the charge box to change the availability to available or unavailable
3.	Change Configuration	To request the charge box to change its configuration parameters
4.	Clear Cache	To request the charge box to clear its cache
5.	Data Transfer	To send vendor specific information to the charge box
6.	Get Configuration	To retrieve the value configuration settings of the charge box
7.	Get Diagnostics	To request a charge box for diagnostics information
8.	Get Local List Version	To request the version number of local list at the charger box
9.	Remote Start Transaction	To request a charge box to start the transaction by sending a remote start transaction
10.	Remote Stop Transaction	To request a charge box to stop the transaction by sending a remote stop transaction
11.	Reserve Now	To reserve a specific connector at the charge box for the use by specific ID-Tag
12.	Reset	To request a charge box to reset itself
13.	Send Local List	To send a local authorization list to charge box for authorization of ID-tags
14.	Unlock Connector	To request a charge box to unlock one of its connector
15.	Update Firmware	To notify the charge box to update its firmware

Figure 7: Operations Initiated by CMS

C. *CMS – Mobile communication*

The mobile application communicates with CMS to enable features and services for EV users. Application resources EV user in finding nearby and well-suited charging stations, check its availability, and reserve / cancel

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its booking at the charging point. It also provides charging history and units used and Time of day (ToD) payment costs in detail. The communication between CMS and mobile applications has other following features. Electric vehicle user registration, update the profile of the user, charging point description, answers of frequently asked questions by the user, Interface with displaying chargers are inoperative or operative, search option for locating charge points.

IV. METHODOLOGY

The purpose of this chapter is to establish an appropriate methodological approach for the analysis of features that participated in exploring the electric vehicle chargers in India. In this chapter, we will discuss the method used for research and the purpose behind the preferred way. We will start with the introduction of available approaches and will focus on why the particular approach is chosen. This section gives a brief idea about the technique used to implement the system. The Open Charge Point Protocol (OCPP) is an internationally recognized leader for the purpose of creating an open application process that allows EV charging channels and the central management system from different vendors to communicate [6].

A. OCPP (Open Charge Point Protocol)

OCPP is the shared language spoken between open electric vehicle chargers and charging station management systems [3]. It is the open-source communication protocol for networked electric vehicle chargers. OCPP aims to make any EV charger work with any electric vehicle charger management software even if the charger manufacturer and developer never met and implementing their products on the opposite side of the world. OCPP does not prefer any EV chargers or software over others. OCPP is free to use as there is no cost for industry stakeholders to adopt OCPP.

B. Evolution of OCPP

The Open Charge Alliance (OCA) is an international organization of public and private infrastructure leaders that have come together to improve open standards. The OCA is an authority that writes and publishes the Open Charge Point Protocol (OCPP). When the OCA was established in 2014, the history of the OCPP goes back to 2009. Below is a brief history of OCPP archives.

There are mainly four different versions of OCPP from the time of its first release. They are OCPP 1.5, OCPP 1.6, and OCPP 2.0 respectively.

1) OCPP 1.2: This version is similar to OCPP 1.5 with fewer functionalities.

2) OCPP 1.5: The standard makes use of Simple Object Access Protocol (SOAP). There are predefined 25 operations in OCPP 1.5

3) OCPP 1.6: This version of OCPP uses 2 frameworks to send messages between sections over the internet SOAP and JSON. To avoid confusion in communication on the type of implementation we recommend using the distinct suffixes -J and -S to indicate JSON or SOAP. In generic terms, this is abbreviated as OCPP-J for JSON and OCPP-S for SOAP.In OCPP-J, OCPP communication over WebSocket using JSON. Specific OCPP versions should be indicated with the J extension. OCPP1.6J means we are talking about a JSON/WebSocket implementation of 1.6. In OCPP-S, OCPP communication over SOAP and HTTP(S). Older versions are considered to be S unless it is specified otherwise, e.g.OCPP1.5 is the same as OCPP1.5S

4) OCPP 2.0: OCPP 2.0 is the latest version released in April 2018, containing many new points raised in 116 use cases. OCPP 2.0 supports JSON. There are many integrated and improved functionalities such as Device Management, Advanced Care Improvement, Additional Security, Smart Charging Performance, ISO 15118 Support, Display, and notification support, and many more extra upgrades requested by the EV charging network without a theme.

Date	Milestone
2009	First version of OCPP is developed and tested in private by ElaadNL
2010	OCPP 1.2 is published (First Public Version of the Protocol)
2012	OCPP 1.5 is published
2014	The Open Charge Alliance is founded
2015	OCPP 1.6 is published; this remains the most popular version of the protocol for commercial deployments
2016	The OCPP 1.6 test Tool is released, making it easier for EV charger manufacturers and software providers to build products that comply with OCPP 1.6
2017	Charge lab joins the OCA
2018	OCPP 2.0 is published
2019	The official OCPP 1.6 certification program is launched
2020	OCPP 2.0.1 is published

Figure 8: Evolution of OCPP

C. Implementation of OCPP 1.6-J

OCPP 1.6 introduces new features to accommodate the market: Smart Charging, OCPP using JSON over Web sockets, better diagnostics possibilities (Reason), more Charge point Statuses and TriggerMessage. OCPP 1.6 is based on OCPP 1.5, with some new features and a lot of textual improvements, clarifications and fixes for all known ambiguities. Due to improvements and new features, OCPP 1.6 is not backward compatible with OCPP 1.5. For a full list of changes Some basic concepts are explained in the sections below. Operations Initiated by Charge Point and Operations Initiated by Central System describe the operations supported by the protocol.

D.*Functional Description*

It follows a functional description of the data that is exchanged between the charging point and the central system during various operations [2].

Figure 9: Sequence diagram

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When a Charge Point needs to charge an electric vehicle, it needs to authenticate the user first before the charging can be started. If the user is authorized then Charge Point informs the Central System that it has started with charging. When a user wishes to unplug the electric vehicle from the Charge Point, the Charge Point needs to verify that the user is either the one that initiated the charging or that the user is in the same group and thus allowed to terminate the charging. Once authorized, the Charge Point informs the Central System that the charging has been stopped.

1) Starting the charge point: Once the charging point has been activated it will attempt to communicate with the central system. The charging point sends a message to the central system that contains the configuration details, brand, and type.The central system will check if the charging point is known in the central system. In that case, the central system then sends a response stating whether the charge point has been accepted or not. If the charging point received response will include the time and date of the central program and the time of the heartbeat. If the charging point is unable to communicate with the central system, it receives a message saying it has not been accepted and will continue to constantly try to communicate with them.

2) Heartbeat: Once the charge point has received confirmation from the central system that it is connected, it will send a heartbeat to the central system at the interval set by the central system after making the connection. This notifies the central system that a charging point is still available. In response to a heartbeat, the central system always sends back the current time and date of the system.

3) Starting transaction: Before an electric car can be charged the owner first needs to authorize the charging action. When the charge pass is made in front of the reader the charging point and sends a message to the central system. This message contains a charge pass ID. The central system then responds with a message stating the validity, expiration date. If the pass rate is allowed the charging point may continue to charge

Stopping Transaction: If the user wants to stop the charging action, they need to identify themselves using the charge pass at the charge point. The charging point then sends a request to the central system to stop charging. This request includes the last meter reading, transaction number, pass ID, and current time. The central system will show whether the user is authorized.

V. RESULTS & ANALYSIS

The integrated implementation flow starts with the User connecting the cable to the charger and vehicle and logging into the application, followed by the charging session at EVSE for the selected slot and the updated charging details at CMS like meter values, duration of charging, the cost for the session and passing the meter values and consumed cost being sent to the user, are developed and tested. For EVSE, the use of OCPP1.5 protocol communication through web services is built and tested. For CMS, a web-based application with OCPP implementation and other features such as the control panel Charging Point (CP) User management, charging stations, interface for EV user from the mobile app for profile creation, assignment to a charge point and calculation of cost for consumed units, user authentication, google maps integration to locate nearby chargers, the payment gateway to facilitate credit/debit/wallet/UPI payments and reserving the chargers remotely in advance is built. A CP user panel is also built to aid the owner of a charging station to add charge points and viewing the transaction details that have taken place in those charging points. Therefore, the complete Central Management System with client and server has been developed based on OCPP with tested mobile and web application.

A. Web app

Below figures shows snapshot of web app. Fig (10) represents the Login Window for Web Application where the charger's owner can log in using an authenticated email ID. Fig (11) represents the Signup window for the owner. The owner can register using the required information i.e name, email ID, contact number, and charger number which will lead the owner for account verification through a link on the registered email ID. Fig (12) shows the information of the chargers and their charge points which helps the owner to monitor them and check their availability. Fig (13) explains the consumption of chargers through a graph.

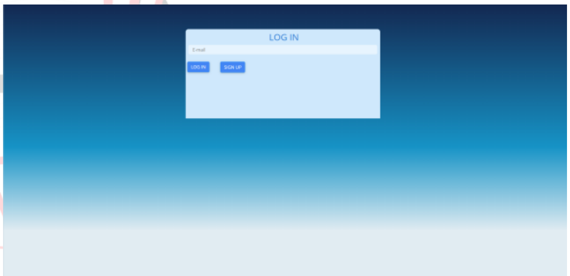

Figure 10: Login window

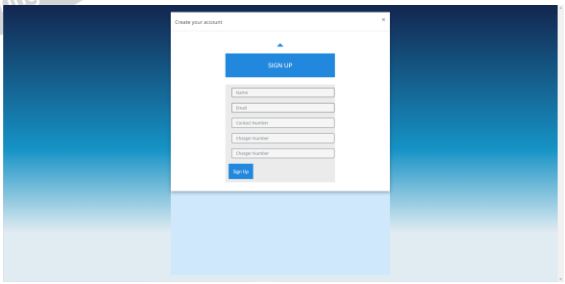

Figure 11: Signup window

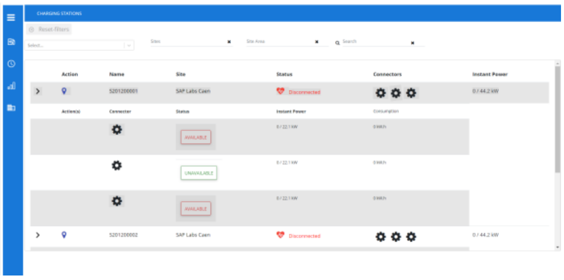

Figure 12: Charger's information

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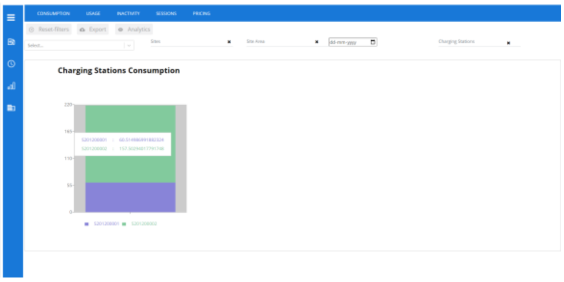

Figure 13: Charging stations consumption

B. Mobile app

Below figure shows snapshot of mobile app. Fig (14) shows user login page. After successful login user will be directed to home page. Fig (15) shows home page. Fig (16) shows payment page. User will pay the bills using UPI. Fig (17) shows start charging page. User will enter charger number and select connector after that user will click on start charging button to start charging of vehicle.

Figure 14: Login page

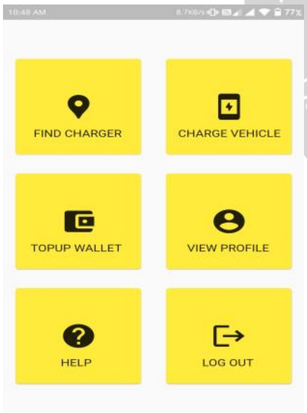

Figure 15: Home page

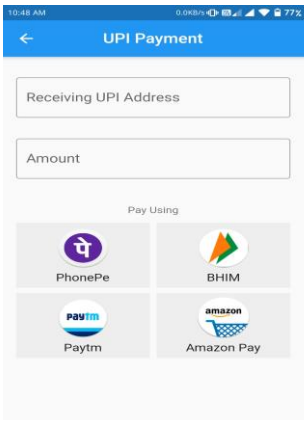

Figure 16: Payment page

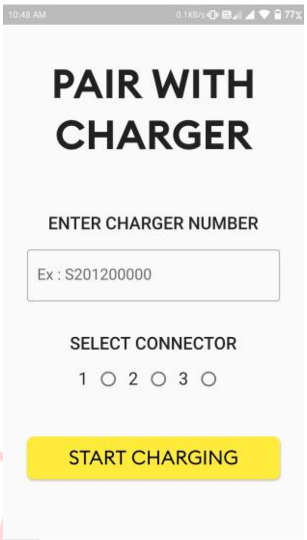

Figure 17: Start charging page

Sr. No.	Parameters	Description – Why this parameter is important for protocol finalization?	Weightage
1.	Implementation Easiness	How easy is it to implement the protocol- Would be easy if it is an extension of something already present	10%
2.	Additional Controller Cost	To check, if any additional controller stands out to be an overhead in the implementation of messages.	10%
3.	Granularity of charging Parameters	Granularity of mandatory/ Optional parameter counts at each stage during the charging – More granular the parameters , richer the protocol is.	15%
4.	Extendibility	The extendiblility supports with further version release	10%
5.	Connector Cost	For economics of scale – What is the cost of the Connector that supports the protocol.	5%
6.	Safety Aspects	Coverage of safety aspects like cable check, welding detection , protection against electric shock, indirect contact, etc.	10%
7.	Supported Charging Modes	Constant current mode / or Constant voltage mode. Some battery chemistry work better based on the charging mode.	10%
8.	Certification Cost	Cost incurred in the certification of the protocol – presumably a one time cost for one version of implementation of the protocol.	10%
9.	Validity period of protocol	To help us to avoid in investing in a protocol that is set to expire in near future.	5%

Figure 18: Evaluation parameters

Fig (18) describes parameters that are important for the evaluation and also provides the weightage given to each of the parameters.

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V. CONCLUSION

In India, the transport sector is one of the fastest-growing sectors. Increasing numbers of vehicles raise local challenges such as deterioration of air quality. However electric vehicles are the future of transportation and are key to have cleaner cities. To fulfill this purpose smart charging is especially beneficial, even essential, for the energy market. Electric charging points may make life easier for people as they provide a provision to charge the vehicle at the time of requirement. With an emphasis on green technology that the world is now beholding, EV industries are one of the largest areas that are poised to grow and contribute to that goal. This paper presents the details of the infrastructure used, EVSE communicates with EV also communicates with CMS using OCPP 1.5 protocol on the other hand. In addition, a portable user application implementation for EVs, with which the EV user contacts CMS for required information and services is explained. This integrated model is an important technology archive that provides an end-to-end solution for charging EV ecosystem infrastructure. This is an important cog on the wheel of the growing EV in India. This paper also addressed various aspects such as their benefits to Electric vehicle owners and their challenges the open research topics for future research.

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REFERENCES

[1] A. Dhianeshwar, P. Kaur and S. Nagarajan, "EV: Communication Infrastructure Management System," 2016 First International Conference on Sustainable Green Buildings and Communities (SGBC), 2016, pp. 1-6, DOI: 10.1109/SGBC.2016.7936090.

[2] Open Charge Alliance “Open Charge Point Protocol 1.6” Available: https://www.oasis-open.org/committees/download.php/58944/ocpp-1.6.pdf

[3] Wikipedia contributors, 'Open Charge Point Protocol', Wikipedia, The Free Encyclopedia, 21 April 2021, 00:29 UTC, <https://en.wikipedia.org/w/index.php?title=Open_Charge_Point_Protocol&oldid=1018998440> [accessed 28 May 2021]

[4] S. Afshar, P. Macedo, F. Mohamed, and V. Disfani, "A Literature Review on Mobile Charging Station Technology for Electric Vehicles," 2020 IEEE Transportation Electrification Conference & Expo (ITEC), 2020, pp. 1184-1190, DOI: 10.1109/ITEC48692.2020.9161499.

[5] L. Prakash, R. Dave, "Charging Infrastructure for Electric Vehicles in India: Policy and Challenges", cyrilamarchandblogs.com, Jan 30, 2020. Available: https://corporate.cyrilamarchandblogs.com/2020/01/charging-infrastructure-for-electric-vehicles-in-india-policy-and-challenges

[6] greenlots.com, "open-standards_white-paper_05", Available: https://greenlots.com/wp-content/uploads/2018/08/open-standards_white-paper_05.pdf

[7] IEA (2020), Global EV Outlook 2020, IEA, Paris https://www.iea.org/reports/global-ev-outlook-2020

[8] B. Roberts, K. Akkaya, E. Bulut, and M. Kisacikoglu, "An Authentication Framework for Electric Vehicle-to-Electric Vehicle Charging applications," 2017 IEEE 14th International Conference on Mobile Ad Hoc and Sensor Systems (MASS), 2017, pp. 565-569, DOI the: 10.1109/MASS.2017.93.

[9] A. Bansal, A. Agarwal, "Comparison of Electric and Conventional Vehicles in Indian Market: Total Cost of Ownership, Consumer Preference and Best Segment for Electric Vehicle", International Journal of Science and Research (IJSR), https://www.ijsr.net/search_index_results_paperid.php?id=ART20181202, Volume 7 Issue 8, August 2018, 683 – 695

[10] RMI India. Electric Vehicle Charging Infrastructure: A Guide for Discom Readiness, 2019

[11] A. Nimbalkar, "List of Top 10 Electric Vehicle Charging Station Manufacturers in India", 18 May 2020, https://evduniya.com/ev-india/list-of-top-10-electric-vehicle-charging-station-manufacturers-in-india.html

[12] EVreporter, "Charging stations providers in India", 17 September 2019, https://evreporter.com/ev-charging-solution-providers-in-india/

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