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A Reliable Sensor Network Infrastructure for Electric Vehicles to Enable Dynamic Wireless Charging Based on Machine Learning Technique

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ABSTRACT In this paper, a hybrid scheme of Dynamic wireless charging (DWC) for electric vehicles EV(s) is proposed to resolve this issue in a network topological infrastructure. The proposed hybrid scheme uses different parameters to allow DWC in EVs. The network infrastructure was established through an enhanced destination sequential distance vector (Enhanced-DSDV) protocol for participating EVs. The DWC charge between paired EV(s) was enabled by magnetic coupling, where the Charge State Estimator (CSE) was used as an unsupervised machine learning technique to learn the current charging status of each EV. Similarly, the captured data of CSE is shared via embedded wireless nodes in the network following enhanced-DSDV routing protocol. Moreover, the proposed model enables each participating EV to transfer charge to another EV participating in the network in DWC environment. To allow, the drivers to monitor the participating EVs in close proximity with their current charge status, location, and distance information, we have have used a dashboard screen in each EV. In addition, each EV uses a generator to produce a magnetic field for magnetic coupling between paired EV(s) to exchange power in wireless environment. The feasibility of the proposed model was thoroughly examined in the real environment of DWC. The results show that the proposed scheme is reliable in terms of DWC in both static and dynamic. Moreover, the enhanced-DSDV routing protocol performed significantly well than existing schemes particularly in terms of throughput, packet lost ratio and latency.

INDEX TERMS Electric vehicles, network topology, charging estimator, electric generator, machine learning, enhanced-DSDV routing protocol, dynamic wireless charging.

I. INTRODUCTION

Electric are gaining popularity in the recent past, due to the environmental change and energy crisis in the world, as an alternative source of transportation. EV(s) are very friendly to the environment, because of its free pollution nature. Developed countries in the world such as China, United Kingdom, and USA take initiatives to resolve the energy crisis in the world with an alternative technology [1]. The governments, researchers, and automobile industries invested a lot of resources around the world to develop an advanced automobile industry of EV(s). The newly adopted automobile industry of EV(s) will have remarkable energy saving capabilities as discussed in the article [2].

To design new improved techniques for EV(s) charging are greatly emphasized on the management of different electrical machines, such as induction machine, magnet synchronous machine and switch reluctance machines [3], [4]. Reference [5] discussed the issues associated with EV(s) grid connectivity during charge transfer. The emphasis of

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this article was to minimize the charging cost and duration. A device known as a current state of charge (SOC) was used to measure the current state of charging in EV(s) [6]. This device was helpful to predict the residual energy of EV(s) in terms of accurate charge detection. The accurate charge detection through SOC plays a vital role during the charging and discharging of batteries because this avoids the full discharge or overcharge of batteries.

Wireless Power Transfer (WPT) technique was introduced in the last decade for DWC in EV(s). WPT scheme uses strict distance parameters while transferring power from one device to another device. References [7], [8] discusses the most recent adopted techniques of DWC for EV(s). Moreover, in the mentioned articles, the size of the batteries was reduced to increase the mileage and speed of EV(s). Inductively Coupled Power Transfer (ICPT) technique was proposed by Elliott *et al.* [9]. The road built-in electric pads were used in ICPT to enable DWC of EV(s). The ICPT scheme scenario diagram is shown in figure 1, where an EV is charging from road built-in electric pads. The ICPT scheme opens the door for the research community to devise new techniques for DWC of EV(s) based on magnetic coupling. However, later-on some flaws were identified in the ICPT scheme, which minimizes its use in the real world. The limitation of the ICPT scheme includes continuous rays transmission form flat pickups and high maintenance costs.

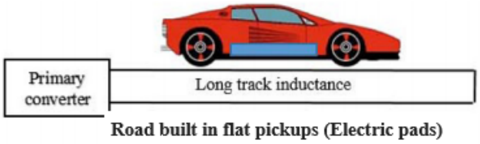

FIGURE 1. Complete overview diagram build in flat pickup to recharge electric vehicles.

References [13], [14] used the pad array-based coupling technique to enable DWC of EV(s). They used several road built-in electric pads to establishes a magnetic field between EV(s) and road built-in pad to transfer power in wirelessly fashion. Figure 2 overviews the detailed scenario diagram of this scheme. In this scheme, each pad has an independent power converter, which enables them to execute independently while transferring power. The infrastructure development and high maintenance cost minimize its use in the real world.

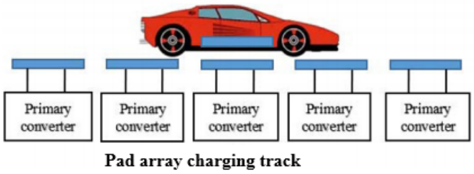

FIGURE 2. Detail overview diagram of pad array charging track, which is used to enable DWC in EV.

In response to roads built-in flat pickups and pad array schemes, the segmental track scheme was introduced to resolve the DWC issue of EV(s) [11], [12]. They used segmental tracks with attached switches and a power converter to enable DWC in EV(s). However, the complex model of the proposed scheme minimizes its uses in the real world.

The double couple method for DWC of EV(s) was proposed by Lee *et al.* [15]. They used the transmitter and moving receiver in their scheme to enable DWC of EV(s). The transmitter and receiver were made of multiple coils, which were operated on a single ON/OFF button. Once, the receiver and transmitter were switched ON, the magnetic fields of transmitter and receiver make an interference through magnetic couping, which was the basic way to transfer charge in the DWC environment. The reflective field idea was suggested by Hu *et al.* [16]. They introduced the concept of automatic switching phenomena in electric pads. However, later on, this technique was failed due to high-frequency transmission throughout the entire process.

Wireless power technology (WPT) had been in use for the last couple of years. They had many applications such as music systems, speakers, sound systems, alarm systems, and electric bells, etc. The adopted techniques of DWC had been briefly described in the ‘‘Korea report’’ [17]. Lee *et al.* [18] proposed the 3rd generation OLEV (On-Line Electrical Vehicle) scheme for DWC of electric vehicles. However, the 1st and 2nd generation scheme of OLEV was in use to transfer power in EV(s) in the DWC environment. The structures used for 1st and 2nd generation OLEV were E-type and U-type environment. The 3rd generation OLEV was named as ultra-slim W-type (dual rail structure), because of its deployment shape.

Ning *et al.* [19] proposed the Telewatt method for DWC of EVs. The city lights infrastructure was used to transfer charge to the EV(s) batteries module in the wireless environment. The magnetic field was generated from the excessive power of city lights (high-density) with EV(s). Similarly, the interference between city lights and EV(s) was established through the magnetic coupling, which transfers power from high density (lamp) to low-density EV(s). The limitation of this scheme was its high-density magnetic field, which had negative effect on the health of pedestal people walking in the vicinity. This disadvantage of the proposed model minimizes its use in the real world. The non-radiative energy transformer scheme was proposed by SL Ho *et al.* [20]. They used magnetic coupling was to transfer power in EV(s) in the DWC environment.

The inductive power transfer (IPT) method for DWC of EV(s) was proposed by Chen *et al.* [21]. This was the first scheme, where DWC of EV(s) was conducted during the motion of EV(s) to minimizes the cost and range issues. Rathod and Hughes [22] proposed the laser power transfer (LPT) technique for DWC of electric vehicles. In this method, power was transferred between the unnamed aerial vehicle (UAV)through LPT. Zhang *et al.* [23] in their survey paper comprehensively overviewed the wireless power transferred (WPT) methods of DWC in electric vehicles. Moreover, they overview the technical aspects such as challenges, working mechanisms, applications, and material involved in the DWC of EV(s). The improved opportunistic wireless-charging system (OWCS) technique for DWC of electric vehicles was proposed by Yin *et al.* [24]. They used an opportunistic hybrid wireless-charging system (OHWCS) and opportunistic stationary wireless-charging system (OSWCS) in their model to transfer charge in electric vehicles in wirelessly fashion. Moreover, this model was capable to exchange power in the static position as well as in dynamic positioning. However, the limitation of the proposed scheme was its complex model, because both the system were made of different battery-reduction models.

The novel two-step technique for DWC of electric vehicles was proposed by Mehboob *et al.* [25]. They used the four-quadrant charger method in their scheme to transfer power in EV(s) in the DWC environment. The main contribution of this research was to eliminate the uncertainty issues while transferring power in EV(s) in the DWC environment. The quasi-omnidirectional technique for DWC of EV(s) was proposed by Han *et al.* [26]. In this method, the direction of wireless transfer systems was considered to transfer maximum charge in the DWC environment. Rakhymbay *et al.* [28] carried out a comprehensive analysis of DWC of EV(s) in their article. The aim of this study was to identify the open research area for research community. The Dual Loop Control Strategy for dynamic wireless charging of electric vehicles was proposed Fan *et al.* [29]. They used multiple transmitter in their model to transfer power to EV in motion. However, the costly model implementation and high magnetic field of aforestated model creates health issues, which minimizes its used in the real environment.

Laporte *et al.* [30] proposed the track built based dynamic wireless charging infrastructure for electric vehicle. They used specific roads, which were contained with electric pad to transfer charge to EV in wireless fashion. However, in real environment designing such a unique road infrastructure is very long term plan. Therefore, the proposed model did not achieved sufficient attention. The road built in pad based wireless power transfer scheme was proposed by Zakerian *et al.* [31] to resolve the load balancing issue in dynamic wireless charging in electric vehicles. To minimizes model cost, the author used input power factor and product of transferred power efficiency to exchange power accurately. However, the health related issues was still unresolved in this model, because during power transfer high magnetic field effects the health of pedestal people walking in vicinity. The road pad finite element based Dynamic Wireless Charging scheme was proposed by De Marco *et al.* [32] to address the aforementioned issue of EVs. Diaz-Cachinero *et al.* [33] proposed a specialized road based infrastructure for dynamic wireless charging for EVs following a series of intersection and decision variable in their model to resolve the dynamic wireless charging issue of EVs. The mobile energy disseminators (MEDs) based dynamic wireless charging scheme was proposed by Kosmanos *et al.* [34]. They used special mobile charging station (MEDs) in their scheme to address DWC issue of EVs. Although, the proposed scheme is used in the real environment, but every scheme has the flexibility of improvement. Therefore, the proposed model is effective in term of EVs DWC, but it needs the availability of mobile charging station in most of the parts of the road, which increases the deployment and maintenance cost with extra manpower utilization at MEDs and technical environment etc,. A comprehensive review paper of the current research direction with previous challenges on DWC of EVs was written by Ma [35]. This paper contains 143 previous research articles with 17 article from the well known institutions such as Institute of Electrical and Electronics Engineers (IEEE)/Institution of Engineering and Technology to set the most effective research direction in the future. Nour *et al.* [36] present a comprehensive review on the negative impacts of DWC of EVs, due to uncontrolled charging, and how these implications can be reduced to an acceptable limit to transfer power in an effective way. Therefore, the positive effects through controlled charging and discharge were evaluated thoroughly in this paper. In addition, the effects of uncontrolled charging of EVs are increasing with voltage deviation from the acceptable limits, phase imbalance, single-phase chargers, misinterpretation of harmonic distortion and overburdening of power system etc, in the existing literature.

The rest of the paper is organized as, section I of the paper overviews the introduction and related work of DWC. Section II of the paper contains the proposed methodology of our scheme. Section III analyzes the experiment results and section IV concludes the paper.

II. LIMITATION OF EXISTING SCHEMES

Dynamic wireless charging (DWC) of electric vehicles (EV) in the current era is one of the hot research areas for the research community. The literature section of the paper comprehensively overviews the existing scheme of DWC. However, due to the development of technologies, system flaws are always identified with the passage of time. Similarly, these flaws are addressed with a possible solution to achieve better results. The limitation observed in the existing literature are as follows:

1) Road build-in pads are very expensive to develop.
2) Road build-in pads needs high maintenance cost with sufficient manpower.
3) Specific roads, which minimize the use of EV.
4) Health-related issues for pedestal people walking in the vicinity.
5) Specific DWC environment such as opportunistic DWC.

A. CONTRIBUTION OF THE PROPOSED MODEL

The main contribution of this scheme is to design a network infrastructure of EV(s), where every participating EV will be capable to transfer power to another participating electric vehicle. Moreover, a dashboard screen is used in each EV to display the collected information of CSE and machine learning technique with the help of embedded wireless nodes. This enables the driver and remote administrator to monitor the participating EV(s) with their charging level, location, distance, and vehicle ID. Similarly, during power transfer, the magnetic field is produced according to the requirement, which resolves the health-related issues of pedestal people walking in the vicinity of these power transfer environment as discussed in the literature. Moreover, this is the first scheme, where every EV is capable to transfer charge to requesting EV in the network, wherever and whenever they request to transfer another EV in the network. Consequently, we have considered other relevant communication aspects of the network, while modifying the ordinary DSDV protocol to enhanced-DSDV protocol. because the ordinary DSDV protocol follows hop count information to transmit data from source to destination. In this scheme, we have enabled roaming capabilities with hop count selection information to improve the communication infrastructure in advanced version of DSDV protocol, because during motion the base station of EVs is continuously changes, if they still follow hop count information in this case.Then lifetime of embedded sensor nodes will decrease with high latency, packet lost ratio and throughput etc,. Therefore, we modified the ordinary DSDV protocol to enhanced-DSDV protocol to resolve this issue by following roaming technique in network through nearest base station to minimize the network cost. Consequently, as far as the novelty concern and our literature knowledge, there is no such a scheme exist, where every EV is capable to transfer charge to another EV in wireless fashion everywhere in the network as per requirement. The aforestated metrics of proposed model not only minimizes infrastructure cost, man power utilization, maintenance cost, but also improves the travel percentage of participating without any tension power constraints.

III. PROPOSED METHODOLOGY: A HYBRID TECHNIQUE OF DWC FOR EV(S)

Electric Vehicles are the substitute technology of ordinary liquid fuel vehicles. Therefore, this technology has a bright future with high impact attention form the research community to design new charging schemes for its power transfer. The introduction section of the paper contains various schemes, but at some stage, they are limited to the system, environment, or complex in their deployment/implementation. Therefore, an efficient scheme is needed to be developed to enable DWC of EV(s) with minimum resource utilization.

In this paper, we proposed a hybrid scheme for DWC of EV(s). Our hybrid scheme is based on the composition of different components such as enhanced-DSDV protocol, CSE, sensor nodes, ML technique, and generator. The proposed model creates a network topological infrastructure, where each EV share their information with other EV(s). Moreover, the proposed model allows the driver to process the charge exchange requests in the network. Besides, the proposed model of this paper use magnetic coupling (MF) technique to exchange charge among paired EV(s) in a static position as well as in dynamic position (motion).

The component composition of the proposed model includes CSE, Electric Generator (G_c), batteries modules (B_j), and wireless nodes, which are installed in each EV. Similarly, all EV(s) are interconnected through the enhanced-DSDV protocol to form a network topology, where they can process information. The CSE continuously measures the current state of charge in each EV based on the ML technique. The enhanced-DSDV routing protocol transmits the collected information, such as vehicle ID, distance, location, and current state of charging in the network, for driver and remote administrator information. Furthermore, the driver will decide power exchanged based on their requirement with other EV(s) in the nearest proximity. The EV has a high charging state (HC_l) in the nearest proximity will be asked to transfer power to the EV having a low charging state (LC_l). Once the EV having HC_l receive the power exchange request from the EV having LC_l. They will accept the charge exchange request and come closer to the requesting EV. Likewise, both the EV(s) ON their generator to generate the magnetic field. The magnetic field of both EV(s) will interfere with each other through magnetic coupling (MC). Once, the coupling has been established, the charge starts transferring from a high charging state EV to the EV having a low charging state. The criteria set for DWC exchange among paired EV(s) in our scheme is about 1.5 meters to transfer maximum power.

Moreover, to elaborate on the concept of our scheme, a network of a variable number of EV(s) (plastic cars) running on batteries was picked. The suggested components are installed in each car to monitor the current state of charge through unsupervised ML. The network topology was formed by connecting all cars through enhanced-DSDV routing protocol to share information with participating cars as well as a remote administrator side. A generator was used in each car to generate a magnetic field for magnetic coupling. Once, the magnetic coupling establishes, the power starts transferring from high power car to low power car. The feasibility of the proposed scheme was checked in the real environment, where the CSE, Electric Generator, and wireless nodes were installed in each participated car and interconnect them through enhanced-DSDV routing protocol to form network topology. Similarly, the base stations (BS) were used in the proposed model to exchange information of the participating cars with the remote administrator.

Example: → Let assume that car A has a low charging state (LC_l) in our proposed network topology. Car (A) generates a power exchange request with the car (B), which has a high charging state (HC_l). After reception of car A request, car B responds with an accepted route reply. Likewise, both cars will come closer to each other to exchange power. Once, they come closer in parallel with each other, both of them turn ON their generator G_c to generate the magnetic field (MF_f).

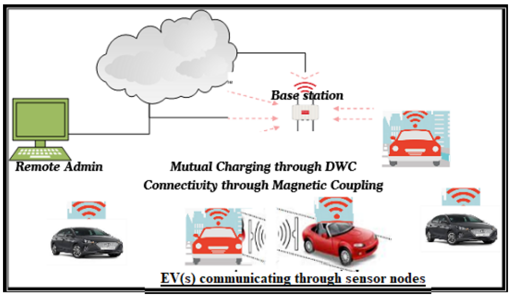

FIGURE 3. Network topology diagram of our scheme, where DWC environment are shown.

The MF_f of both cars make an interference with each other through magnetic coupling MC_c. Once, the MC_c establishes the power will start flowing from high level to low level in wireless mode (which is known as DWC). Now the process of DWC will continue until both the powers are equalized in paired cars. However, the proposed scheme also allows the drivers to stop the charge transfer process at any stage by switching OFF the generator G_c.

Moreover, the ML technique of CSE plays a vital role in this phase, because it shares the current power exchange information continuously in the network, which enables the drivers of Car A and B to stop the exchange process at any stage (as per their requirement). The detailed overview diagram of the proposed scheme is shown in figure 3.

Figure 3 of the paper presents the network overview diagram of our proposed scheme. The EV(s) are shown in the figure communicated their information through embedded wireless nodes in the network. Furthermore, each EV communicates with other participating EVs directly in close proximity. Similarly, the EV broadcasts a route request (RREQ) message in the network, which contains vehicle ID, power and distance information of EV. The EVs in the close proximity receive this route request (RREQ) and respond with a route reply (RREP) message, which also contains information such as vehicle ID, charge of state and distance. Moreover, the base station is used in the network to maintain the reliability metrics and extend the network connectivity to the remote administrator. The remote administrator monitors the entire network topology through base station connectivities. Furthermore, the administrator as a whole looks after the network to maintain performance reliability.

A. OVERVIEW OF ENHANCED-DSDV ROUTING PROTOCOL

The proposed enhanced-DSDV routing protocol uses the distance vector information to advertise participating EV(s) information such as vehicle-ID, charge of state, location, and distance in the network. Similarly, the participating EVs embedded sensor nodes follows these information to share their collected data in the network through hop count and BS with other EVs. Moreover, the over network is monitored at remote location with the help of an administrator. The remote administrator is a valuable part of our proposed model because he plays a major role to maintain the reliability metrics in the network.

Subsequently, to elaborate on the role of enhanced-DSDV routing protocol in the proposed model, it establishes link with neighboring EV(s) to update the routing table accordingly. Likewise, the participating EVs of the network share information with each other in close proximity via hop count and with other EVs through BS(s) connectivity. Furthermore, the modification part of our enhanced-DSDV protocol is that it is capable to update the routing information of participating EVs, when they are in moving position and the base station changes, but they still maintain same consistency as like close proximity hop count information. When the base station changes during the communication process, then the same EV roam to another BS and continues its communication process in the network with the same accuracy.

Theorem-1: EV A_i generates a power exchange requests with an EV B_i having high charging state HC_l. A_i power exchange request is forwarded through enhanced-DSDV routing protocol to B_i. After observing dashboard D_b screen information, the driver of B_i responds to A_i request as **Accept**.

Proof: Let assume that EV A_i generates a power exchange request with an EV B_i having greater HC_l by sending its ID, location and distance information. A_i broadcasted message is also sent to remote administrator. B_i, check its D_b screen information, where he found A_i power exchange power request. B_i EV, which has high charging state HC_l, responds A_i request with an accept reply. The accept message is forwarded in the network by means of broadcast message. Likewise A_i and B_i EV(s) come closer to each other in parallel to exchange power.

Conversely, if B_i doesn't respond to A_i request, A_i will regenerate an alarming message in the network for remote administrator, where he will B_i to communicate with A_i for power transfer.

Algorithm -1 of the paper shows, the detailed overview of forwarding, storing route request (RREQ), and route reply (RREP) information in the network. Let assume that A_i and B_i are two EV(s) belong to N_{n-1}. A_i EV initiates a power exchange request with B_i EV in the network. B_i receives A_i RREQ and responds with an accept message to transfer power. Likewise, if B_i did not responds A_i RREQ, then A_i regenerate the RREQ packet in the network. The remote administrator also receives A_i RREQ. Once, the remote administrator receives A_i power exchange request with B_i EV in the network. The remote administrator will make a direct communication request with B_i EV to acknowledge the A_i power exchange request. Similarly, the remote administrator will ask B_i to accept the A_i power request and transfer charge to A_i. In this manner, the enhanced-DSDV protocol enables the participating EV(s) to communicate and process power transfer requests in the network.

B. CHARGE STATE ESTIMATOR (CSE) AND ELECTRIC GENERATOR: DWC ENVIRONMENT

The charge state estimator (CSE) is used in each participating EV to measure the current state of charging. The battery model used in the proposed scheme was based on series

Algorithm 1 Algorithm for Enhanced-DSDV Routing Protocol While Broadcasting Power Exchange Request in the Network

```
Require: Communication among participating EVs:
Ensure: Vehicle ID, distance and location:
  DATA
  $A_i$ initiate power exchange request
  $A_i$ Broadcast RREQ packet
  which contains (vehicle-ID, charge and distance info)
  EV $\in N_{n-1}$ in close vicinity $\leftarrow$ Respond with RREP
    (if)
      Where $B_i$ is the closet EV with $HC_l$.
        $B_i$ Respond $\leftarrow$ RREP message
        Accept
          (Else-if)
          $A_i$ regenerate request $\leftarrow$ with $B_i \in N_{n-1}$ EV(s)
          Remote admin $\leftarrow$ Receives $A_i$ EV Request
          admin $\leftarrow$ Acknowledge $B_i$ the request of $A_i$
          $B_i$ responds $\leftarrow A_i$ RREQ
          $A_i$ & $B_i$ $\leftarrow$ Come closer in parallel to transfer
  power
        end
      Next step Repeat
    Return $\leftarrow$ EV(s) current information
  end
```

connectivity, where each battery has the same charging and rating capacities. Similarly, the information captured by CSE during machine learning was further linked with embedding wireless nodes. Interconnect the embedded wireless nodes of EV(s) in the network topological infrastructure through Enhanced DSDV routing protocol. The participating EV(s), were prepared with a dashboard screen (D_{bc}) to enable drives to observes close proximity traffic. Moreover, the D_{bc} also allows the driver to process the power transfer request with an EV, who is in their vicinity. The importance of CSE with the machine learning technique increases when the power transfer took place among paired EV. During power transfer, the current status is captured by CSE via ML techniques, which is instantaneously shares in the network including donor and accepter EV(s). Consequently, a generator G_c is used in each EV to generate MF to enable MC. The G_c has an additional property to maximize the current rate by 50 % percent from its original state of extracting current from the donor EV while transferring charge. This makes the charging process faster with minimum energy wastage in the DWC environment. The charging transfer conducted in this research is power-bank-to-power-bank among the different EV(s).

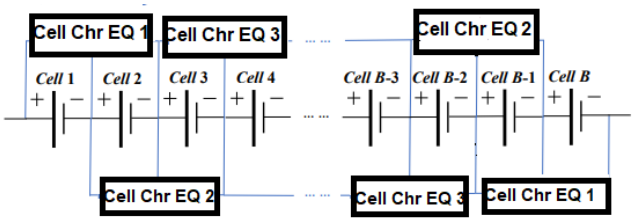

FIGURE 4. The series based connectivity of batteries module are shown in this figure.

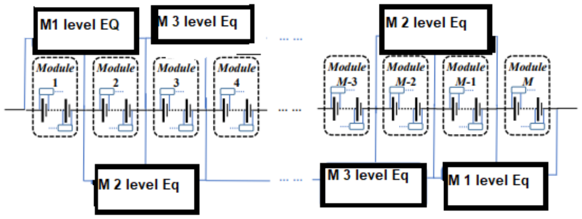

FIGURE 5. shows the detail overview of series based connected module to equalize charge.

C. SERIES BASED BATTERIES CONNECTIVITY IN MODULE TO MODULE ENVIRONMENT

Figure 4 of the paper shows the series based connectivity of batteries, which is used in our proposed scheme. However, the charge is automatically equalized in each module (battery bank). In case of power transfer, when the magnetic coupling is established among paired EV(s). Then the charge flows from high charing state to low charging state EV. Furthermore, the equalization of charge in each module is shown in figure 5. The module-based connectivity of batteries for the proposed scheme is shown in figure 5. Let assume that on the left side of the figure is the battery bank of EV (A_i) and on the right side of EV (B_i). The B_i EV module has a greater charging state in our assumption. A_i initiates power exchange request with B_i and B_i accepts A_i request to transfer power. The B_i module will transfer charge to A_i module until the power of both modules became equal because the batteries are connected in series in both of the modules. Furthermore, a CSE is attached with each battery module to measure the state of charging SC_l of installed battery bank as shown in figure 4. The series based connectivity of batteries in the proposed model equalizes the charging state according to figure 4 illustration. Moreover, the modules M_{n-1} with a state of charge SC_l is equalized through the Equalization scheme, such as series connectivity of batteries to maintain maximum power level in each module, where M is used for module of batteries.

Furthermore, the concept of DWC is explained by the functionality of the proposed model. When the EV(s) come closer to each other in parallel for the sake of transfer power, they ON their G_c to generate MF_f for magnetic coupling. Once, the MC_c is establishes among the paired EV(s). The charge start flows from EV having high HC_l to the EV having a low charging state LC_l. The donor EV releases the charge with a 50 % extra current, due to the G_c doubling property to convert original current to 50 % extra current. The accepter EV accepts the released charge of at the same rate, in this way the charge is transferred among paired EV(s) in a quick way with minimum energy dissipation.

When high power module M_h release charge R_c toward low power module M_l, then M_l accept R_c of M_h as a unit charge. The charging state of M_h module decreases, when R_c releases the charge toward M_l module during power transfer. Moreover, the charging state of accepter EV M_l module is increasing by $(1-l_c)R_c$. The module charging system for EV as choosed in this research is battery cells B_i, where the i-th cell of the battery is $B, S \in M$ module $\lceil \frac{i-th}{B} \rceil$. The n-th cell of B during charging access or transfer from its adjacent B, B_i is illustrated by the following EQ. The equations for transfer of charging for figure 3 and 4 is represented subsequently.

$$T_i^{cl}(n) = \left\{ \begin{matrix} smgl\ ((-\Delta^{m_n}_{i-th})\ (n-1),\ L_{m_n})\ r_{m_n}, \\ If\ \lceil \frac{i}{B, cell} \rceil - 1 > 0 \end{matrix} \right\} \tag{1}$$

$$T_i^{cr}\ (n) = \left\{ \begin{matrix} smgl\ ((-\Delta^{m_n}_{i-th+B})\ (n-1),\ L_{m_n})\ r_{m_n}, \\ If \lceil \frac{i}{B, cell} \rceil + 1,\ \leq\ (M)\ module \end{matrix} \right\} \tag{2}$$

The smgl in equation 1 and 2 represents the power dissipation.

The difference between H_c and H_l is:

The difference in state of charge $(C_l)^{module(M)}_{Hc}$ (n-1) $= \Delta^{module(M)}_{Hc}$

$$\begin{aligned} &(C_l)^{module(M)}_{Hc}(n-1) \\ &\quad = \overset{(M)}{\underset{Hc}{\Delta}} \\ &\quad = \left\{ \begin{matrix} \sum_{j=\lceil \frac{H_l}{B, cell} \rceil -1}^{\lceil \frac{H_l}{B,cell} \rceil}, & y_j(T_n-1) \\ -\sum_{j=\lceil \frac{H_l}{B, cell} -2\rceil (B+1)}^{\lceil \frac{H_l}{B,cell} -1\rceil}, & y_j(T_n-1) \end{matrix} \right\} \end{aligned} \tag{3}$$

smgl is defined in equation 1 and 2, where the difference between H_c and L_c is defined by 3

The total transfer charge is denoted by T^{trans}_{total}:

$$T^{trans}_{total} = \left\{ T^{R^c_a} + T^{R^c_t} + T^{cl}_i\ (n) + T^{cr}_i\ (n) \right\} \tag{4}$$

The magnetic coupling connectivity of our scheme is shown in 6. The two coils are shown in figure reffig6 : 6 with an attached generator to generate MF for MC. Once, the coupling establishes the transmitting coil transfer charge to the receiving coil. In this way, power is transferred from one EV to another EV in our proposed scheme.

D. PROPOSED MODULE OF DYNAMIC WIRELESS CHARGE (DWC)

In this section, the DWC environment of our proposed model is comprehensively overviewed. The basic functionality of DWC is shown in figure 6, where the charge is transferring from one coil to another coil through magnetic coupling MC. The Generator G_c is used to generate a magnetic field. Furthermore, the generated MF of two parallel EV(s) makes an interference with each other, which is known as magnetic coupling MC. Once, the magnetic coupling establishes, the EV has high-level charge starts transferring charge to the requesting EV with the 50 % extra ratio of the original charge of the donor EV. However, in this scheme, we have used a generator in each participating EV, which have the current doubling capability with designed coil deployed in EV(s).

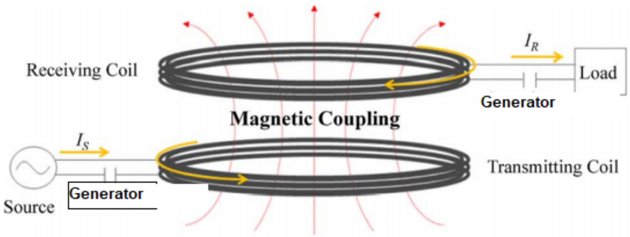

FIGURE 6. **Overview diagram of charge exchange among two coils through magnetic coupling, which is used in our scheme.**

In this section, the DWC environment of our proposed model is comprehensively overviewed. The basic functionality of DWC is shown in figure 6, where the charge is transferring from one coil to another coil through magnetic coupling MC. The Generator G_c is used to generate a magnetic field. Furthermore, the generated MF of two parallel EV(s) an interference with each other, which is known as magnetic coupling MC. Once, the magnetic coupling establishes, the EV has high-level charge starts transferring charge to the requesting EV with the 50 % extra ratio of the original charge of the donor EV. The power maximization is the functionality of generator G_c to maximize the extracted power by 50 %, while releasing it toward the accepter EV. The 50 % excessive power conversion property of generator speed-up the power transfer among paired EV with minimum energy dissipation. Moreover, this also ensures the maximum power transfer to accepter EV from donor EV extracted power. Similarly, the acceptor EV accepts the power with this ratio to speed-up the power transfer process with minimum energy consumption and time. The distance parameters were set about 1.5 meters to transfer maximum charge in the wireless environment. The EV(s) moving on the road are also capable to transfer charge during their motion if they follow the parallelism and distance parameters.

If an EV wants to transfer or recharge its battery module it needs to make an interface with other EV through MC. The position of both EV(s) should be according to the specified distance and parallelism to transfer maximum charge. Systematically, the generator should be the part of each EV to generate MF for MC, when in motion, or in a static position to transfer charge. The generator is set like to generate a constant resonant frequency to maximize the transfer of charge among EV with greater efficiency. A bridge-type inverter is used in each EV to maintain a constant current rate of 22 kHz during the process.

1) MATHEMATICAL MODEL FOR MC: DURING DWC

In the proposed model each EV has a build-in coil, which is used to produce a magnetic field. Once, the generator is

ON, while transferring charging from one EV to another EV. The build-in coil designed for DWC becomes operational and produces a magnetic field. Similarly, the other EV sharing power also ON their generator to produce a magnetic field. The magnetic field of two parallel EV(s) in the proposed model interferes with each other. Once, the magnetic coupling interference establishes among paired EV, they start transferring power to each other.

Let assume that the mutual inductance between two coils is given by the following formula:

$$Mutual\ Inductance\ (M) = \frac{N_1 * N_2 * \mu_0 * \mu_r * A}{l} \tag{5}$$

In equation 5 (N) denotes the number of turns in each coil. Similarly, symbol (A) is used for cross section area and (l) for the coil length. The permeability of free space and iron core is subsequently denoted by μ_0 & μ_r.

The mutual inductance of an individual coil such as $coil_1$ and $coil_2$ can be determined by equation 6, where current flows from $coil_1$ to $coil_2$ or $coil_2$ to $coil_1$. Keeping in view the position parameters.

$$M_{12}\ orM_{21} = \frac{\phi_1 2 * N_2}{l_2} \quad OR \quad \frac{\phi_2 1 * N_1}{l_1} \tag{6}$$

However, the coupling factor is denoted by k. where k is:

$$k = \frac{M}{\sqrt{coil_1 * coil_2}} \tag{7}$$

Likewise, the self inductance of an individual coil can be determined by:

$$Coil_1 = \frac{N_1^2 * \mu_0 * \mu_r * A}{l} \tag{8}$$

OR

$$Coil_2 = \frac{N_2^2 * \mu_0 * \mu_r * A}{l} \tag{9}$$

To calculate the mutual inductance between two coils in term of self-inductance. Multiply equation 8 & 9. So we get:

$$M = H\sqrt{Coil_1 * Coil_2} \tag{10}$$

E. ANALYSIS OF PROPOSED SCHEME: ENHANCED-DSDV, CSE, GENERATOR AND DWC

The proposed model is collectively overviewed in this section of the paper. Furthermore, the correlation steps adopted in the proposed scheme to achieve DWC are analyzed comprehensively. The enhanced-DSDV protocol is used to establish communication infrastructure and share related information in the network. The RREQ and RREP messages of EV(s) contain the necessary information such as distance, vehicle-ID, state of charge and current location, etc., to enable drivers to forward power exchange requests in the network. The following algorithm represents the step by step process adopted in this regard. The Shortest Distance of EV is represented by SDSN (EV_{n_i}, M), Where $EV \leq n$ and $m \leq i$. The brief algorithm is shown herewith to identify the nearest EV through Enhanced-DSDV protocol to enable DWC through magnetic coupling MC.

Algorithm 2 Proposed Enhanced-DSDV Computational Algorithm for Shortest Distance of EV to Enable DWC

```
Require: Identify EV with minimum distance in the nearest proximity
Ensure: Return Shortest distance Subsequence ID of EV ($SDSN$)
  Curr-SDSN ← 0
  Start ← 0
  Start Sequence-No ← 0
  for i ←0; i < n; i++
  do
    for i ← i ∈ EV(s)-ID % charging module $M$
      do
        for j ← Sequence-No → $M_n$ AND $A_i \in \delta$
          if EV or M = 0 then
          SDSN ← 0 There should be no path
          elseif $A_{i,n} == Batt_{j,m}$ Then Return
          EV Sequence-No ← $j + 1$
          Count ← Sequence-No + 1
          communicate with participating EV(s)
        end if
      end for (statement)
    if Sequence-No in Close proximity → Count ← Sequence-No to +1
    then
  Update Sequence-No in dashboard screen of EV(s) ← Sequence-No + 1
```

Algorithm 2, of the paper illustrate the steps wise procedure of our proposed protocol to identify the closet EV in the close proximity for power exchange.

Definition: SDSN = (0, 0) are taken when there is no vehicle in the nearest proximity.

Definition: The algorithm steps of $SDSN \in$ EV and MC_c). All the steps of DWC are shown in the above algorithm, which is followed throughout the entire process of our proposed scheme to enable DWC. To elaborate on the concept of the defined algorithm. The steps adopted in the mentioned algorithm overviews the detection of EV in the nearest proximity. Likewise, all the participating EV(s) broadcast their RREQ and RREP messages in the network, which contain their vehicle ID, distance, location and charging information. Once, an EV generates a request for power charge with the nearest EV, whose ID, distance and charging information is visible to requesting EV on D_b screen. Then, the requesting EV broadcast a message packet to forward their power exchange request in the network and specifically with the nearest EV having HC_l. The communication took place between low charging state EV and high charging state EV. Then the nearest proximity EV accept the power exchange request and come closer to the requesting EV to transfer power.

Algorithm 3 Consequent Steps of Algorithm for Our Scheme Is Continuous to Complete the Process of DWC

```
  Update Sequence-No $\leftarrow$ Sequence-No + 1
  After identifying the sequence number of EV the following steps should be adopted to complete the DWC process
  Replace
Prev-SDSN
  $\leftarrow$ Curr-SDSN $\leftarrow$ Such as EV ID and distance & location information
  if
    EV $\leftarrow$ nearest proximity
      Then
        EV $ID = i = A_i$ $\leftarrow$ Where $i = i++$
          EV ID = $A_i$ $\leftarrow$ Requested for DWC
          if
            EV $B_i \in A_n - 1$ $\leftarrow$ Accept $A_i$ Request
              The requested EV $A_i$ $\leftarrow$ Path $\leftarrow$ 0
              Then
              $A_i$ EV Start its $G_c \leftarrow MF$
              $B_i$ EV also Start its $G_c \leftarrow MF$
                if
                $A_i$ and $B_i$ $\leftarrow$ makes an interference $MC$
                $MC \leftarrow A_i$ & $B_i \leftarrow 0$
                EV $B_i$ transfer power $\leftarrow$ EV $A_i$ (DWC)
                elseif
                The EV(s) $\leftarrow MC \neq 0$
                DWC in EV(s) $\leftarrow$ Doesn't take place
              end elseif
            end if (statement)
          Next
        end if (statement)
    end for
  return The EV-ID $\leftarrow$ charging status
```

The experiment was performed in the real environment, where dynamic numbers of plastic cars were chosen. They have embedded wireless node, Generator and CSE to collect information based on ML and process it for further communication in the network. Connect all the participating EV(s) through the enhanced-DSDV routing protocol to share their collected information with individual EV(s) and as well as in the network.

F. MACHINE LEARNING UTILIZATION IN THE PROPOSED MODEL

In the proposed scheme, we have used an unsupervised machine learning technique known as variational auto-encoders to enable DWC in EV(s). The variational auto-encoders algorithm performs significantly well over the existing unsupervised techniques such as hierarchical learning, data clustering outlier detection and reinforcement learning in terms of critical aspects predication [27]. The variational auto-encoders algorithm was used to monitor and acknowledge the critical aspects of batteries modules such as an unintentional change in an individual module, charging level predication, and accidental change in the CSE behavior. The variational auto-encoders algorithm continuously assesses the batteries modules installed in an electric vehicle to detect the predicated changes in their nature or behavior, which minimizes the failure chance of battery modules and extend their lifetime. Similarly, the variational auto-encoders algorithm predicates the charging levels in terms of below critical condition and excessive charging condition, which also play a vital role to maximize the lifetime of installed battery modules. Moreover, the unsupervised variational auto-encoders algorithm also assesses the behavior of CSE to predicate unintentional changes. The unsupervised machine learning technique in the proposed scheme maintains the reliability metrics, which ensures the effectiveness of DWC in network topological infrastructure with accurate information exchange.

IV. EXPERIMENTAL RESULTS AND ANALYSIS

The proposed scheme was checked in the real environment to enable DWC among paired EV(s) by taking plastic cars with defined parameters. The EV(s) of the proposed model were interconnected in the network topological order. Moreover, the unsupervised machine learning technique used to monitor the critical aspects of charging modules in coordination with CSE, sensor nodes, and enhanced-DSDV routing protocol. Moreover, the participating EV(s) uses their built-in unsupervised ML technique, CSE, and embedded wireless nodes to work according to their assigned task. The CSE was used to measure the current state of charging and pass through the collected information to the embedded wireless node. Similarly, the unsupervised machine learning technique with it's specific variational auto-encoders algorithm was used to detect the critical aspects of the system. The network connectivity of embedded wireless nodes was made through the enhanced-DSDV routing protocol to transmit the collected information in the network for participating EV(s) and remote administrator. In the proposed model, once, all the participating EV(s) were connected in network topological order with their built-in configuration. A test communication message was exchanged to verify the operational reliability of the proposed scheme with requested information in the network. After, successful communication in the network, one EV having a lower charging state was checked to initiate a power exchange request with their vicinity EV having high charging state. The communication between both interested EV(s) took place successfully and they were brought closer to each other for the exchange of power. Once, both EV(s) come close in parallel with a distance of 1.5 meters, both of them ON their generator to produce MF and make an interference through magnetic coupling (MF). After the establishment of MC the charge starts flowing from EV having a high charging state to EV having a low charging state. The current status of current was continuously observed from both EV(s) dashboard screen to verify the accuracy of the proposed model with CSE and enhanced-DSDV routing protocol information. Moreover, digital multimeter (DMM) and packet analyzer were used as a tool and tester to verify the collected information of the dashboard screen of an EV with different locations manual reading in the network.

The performance reliability metrics checked during experiment results for proposed scheme includes DWC charging efficiency in motion and static position, packet lost ratio, end-to-end delay, throughput. The enhanced-DSDV protocol results were evaluated for packet loss ratio, when the EV(s) were communicated through hop count (directly) and also for indirect communication, when base station was involved in the communication process. Moreover, the throughput and end-to-end delay statistics were also observed for enhanced-DSDV protocol to verify the performance reliability in the operational network.

The CSE(s) were linked to embedded wireless nodes to shared the collected information in the network. Likewise, the network infrastructure was designed so to share the collected information of CSE with an individual EV in the close proximity (direct connectivity through hop count) and also with the involvement of base station at the remote location (including network administrator). During experiment the collected information of an individual EV about CSE was capture and compared with the manual check results to ensure the assessment of CSE or collected information of CSE. Moreover, the dynamic numbers of EV(s) having the low charging state were checked to launch a power exchange request with the EV(s) having a high charging state. After that, the high charging state EV(s) respond with an accept reply. Both vehicles were brought closer to each other at a parallel distance of 1.5 Meters to transfer power in DWC fashion. Once, both EV(s) come closer, the generator G_c of both EV(s) were ON to initiate the magnetic field, after initiation of MF, both the vehicles were make an interference through magnetic coupling. The EV has a high charging state starts transferring power to the EV having low power. Similarly, during power transfer, the results of the state of charging for EV(s) were observed from EV(s) dashboard screen and also at remote location admin PC to verify the reliability of collected data at local end and remote site. The result observed during experiment analysis is shown one by one in the upcoming paragraphs. The parameters used to perform this research task are shown in table 1:

TABLE 1. **Data set parameters taken for proposed scheme implementation.**

Parameter Types	Parameter
Simulation Environment	Real Environment
Electric Vehicles EVs	10, 20, 30, 40, 50
Generator G_c	G_c 1 for each EVs
Wireless nodes (A_i)	As per EV numbers
Tower of gateway	15 meters
Gateway/Base stations	3
Charge state estimator	As per EV numbers
Batteries	according to M modules
Routing Protocol	enhanced-DSDV
Packet size	128 Kbps
Remote administrator (PC)	1
Charging Environment	DWC
Range Transmission T_x	800 m

A. CHARGING MODULE BASED RESULTS ANALYSIS FOR DWC

The module-based connectivity of batteries for the proposed model is shown in figures 4 and 5, where all the batteries were connected in series. They have the same charging, recharging and rating capacity when connects to the source of power for recharging. This certifies that charging and discharging of module doesn't affect these batteries when equalization the charging state in these modules. During experiment analysis, a recharge request message was generated by an EV in the network. The request message was forwarded through the enhanced-DSDV routing protocol in the network and all participating EV(s) respond with a route reply message, which contains vehicle-ID, distance, charging and location information. The charging status of all replying EV(s) was observed from the dashboard screen of requesting EV. The EV, which has a greater charging state in the nearest location was sent a power exchange request. similarly, the driver of the said EV responds with an accept route reply message. After, successful communication both EV(s) were brought closer by a continuous communication exchange message in the network through the enhanced-DSDV protocol. After reaching both EV(s) to a specified nearest distance, the generator of both EV are ON to generate a magnetic field for magnetic coupling MC. EV having high level SC_l ON their G_c in parallel with requesting EV, the to generate magnetic field and establish an interface through MC to transfer power. After, MC the charge start transferring form EV having high charging state to the EV having low charging state.

A bridge-type inverter was used with each generator to maintain a constant current of 22 kHz in transmitting coil and receiving coil to transfer maximum power to the requesting EV. Once, the magnetic flux was established in the process, the transmitting coil transfer 210 Amp current to the receiving coil through MC. The width of the receiving and transmitting coil is set about 90 cm with the air gap between pair EV(s) to transfer maximum power. The air gap, which was (90 cm) among paired EV(s), the charge transferred was observed about at the rate of 110 kW to equalize the charging state in the requesting EV (charging module). The current status information of power exchange was continuously broadcast through the enhanced-DSDV protocol that both the drivers will monitor the current power statistics form their dashboard screen. The performance efficiency of the proposed model was also seen when the distance was varied among the paired EV. When the distance was minimized among the paired vehicle the charging rate was seen slowly degraded as compared to the 1.5 meter distance.

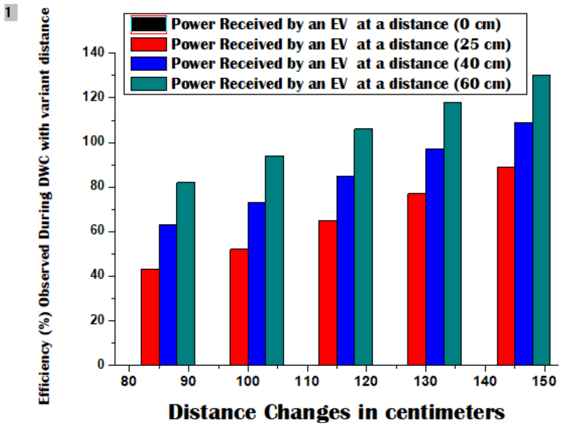

FIGURE 7. **DWC efficiency measurement while transferring charge among EV based on distance metrics in the static position.**

During the experiment analysis, all the information was observed from the paired EV(s) dashboard screen and remote administrator screen. The CSE was found to contentiously generates the results statistics about the current state of charging in both EV(s) and enhanced-DSDV protocol broadcasts the collected information in the network. The wireless nodes transmit the collected information of CSE in the network with the help of enhanced-DSDV protocol, which enables the driver and administrator to monitor the recharge level in requesting EV and discharge value in the donor EV. The results observed during the experiment in the real environment from EV(s) dashboard screen and administrator PC screen while transferring power between paired EV(s). The results were quite convincing in terms of power efficiency during power exchange and communication metrics such throughput, end-to-delay and packet loss ratio. The power was exchanged among paired EV(s), where the distance parameters were changed dynamically to overview the result statistics. The first statistical analysis of power exchange was observed when the distance between the paired EV(s) was 1.5 meters. The efficiency observed during results analysis for 1.5 meters distance was about 89 %, when two paired EV(s) were transferring charge in DWC fashion. Similarly, in the next statistical analysis, the distance was disturbed from 1.5 meters to 40 cm. At a distance of 40 cm the results captured for DWC among paired EV(s) was 85 % and in the consequent step the distance was changed to 25 cm, where the results statistic observed for DWC was 82 %. The distance between paired EV(s) was changed to verify the strength of MC, while transferring power between paired. However, after changing the distance parameters between paired EV(s), the power conversion rate was found effected from statistical analysis. The statistic shown for DWC in figure 7 was observed during static position of EV(s) to transfer power. Similarly, figure 8 represents the DWC statistics when the EV(s) were in parallel motion with a variant speed up-to 5 km/hour. The parallelism and distance parameters during result analysis were strictly observed to verify the results, while transferring charge from one EV to another EV. Consequently, figure 12 graph of the paper represents the DWC statistic based on distance metrics, when the EV in motion, while transferring charge to other EV.

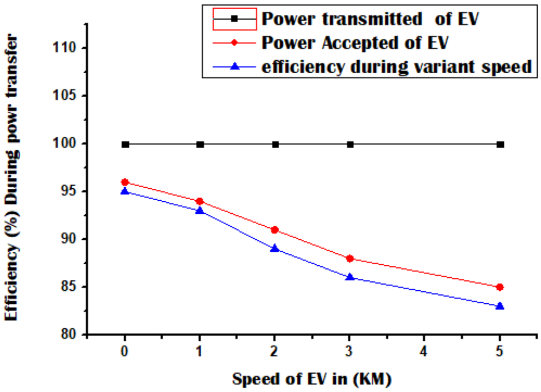

FIGURE 8. **DWC efficiency measurement while transferring charge among EV based on distance metrics, when EV(s) are in motion.**

B. RESULT ANALYSIS OF CHARGE STATE ESTIMATOR AND MACHINE LEARNING: CSE & ML

The results accuracy of CSE and machine learning were checked with the dashboard and remote administrator screen by the physical power measurement results in participating EV(s). The analysis was made by collecting current charge state information from an individual EV dashboard screen and an administrator's PC. The collected information about the state of charging of each EV(s) was compared with manual check reading of digital multimeter (DMM) based on vehicle ID. The result found during analysis was quite consistent with the individual EV results collected from the dashboard screen and administrator PC with physically extracted readings. Likewise, all the dashboard collected reading was matched with manual checks in different locations of the network to verify the accuracy of CSE captured results. The results were fond matched all over the network, which verifies that the proposed model was quite consistent in terms of CSE. Similarly, the machine learning technique was verified by an intentional change in the batteries modules. The Charging status of an individual battery module was down by shorting its terminal. Once, the battery module starts a continues charge-discharge in an embedded battery box, the ML technique actives by broadcasting a predicating alarm message. Likewise, to assess the prediction of ML technique in the proposed scheme, the charging level of an individual battery module was increased to its excessive threshold value. In this case, ML technique was also found activated by broadcasting an acknowledgment message.

C. EFFECTIVENESS OF OUR SCHEME OVER THE EXISTING SCHEME IN TERMS OF UNDERMENTIONED METRICS

The effectiveness of proposed scheme over existing scheme in terms of travel percentage, road selection, power exchange availability, and every EV power transfer capability shows significant improvement. As far as literature concerns, most of the existing techniques uses special routes/road, MED, or special environment to transfer power to EVs. Although, our scheme also uses the magnetic field coupling environment to transfer power to another EV in the network, but our scheme enable each participating EV to transfer power to another EV everywhere, anywhere in the network as per requirement, which eliminate the tension of availability of road built in pads, special roads, or special environment. Moreover, the participating EVs of our scheme share their data in the network, which enables drivers and administrator to detect or communicate EVs in the network. This special property of our scheme allows the EVs companies to develop network infrastructure without any special requirement in the real world DWC of EVs. Likewise, during power transfer situation, the embedded wireless nodes communicate normally without extra overhead or congestion and contention etc. Therefore, the results extracted for communication metrics showed better result statistics. Consequently, every EV has a unique ID, which differentiate it in network form other EVs to be communicated or identify its location, and charging level. Similarly, the proposed protocol has the flexibility. The flexibility parameters of this scheme create an opportunity for our previous MAC-AODV schemes [37] to be utilized in combination with proposed model to ensures the integrity, confidentiality and availability of data in the network.

D. RESULT ANALYSIS OF ENHANCED-DSDV ROUTING PROTOCOL

The results of the proposed scheme was also evaluated for enhanced-DSDV routing protocol based on the aforementioned metrics, such as PDR, end-to-end delay, and throughput. The enhanced-DSDV routing protocol allows all the electric vehicles to share their information with other participating EV(s) based on distance vector. Moreover, the collected information was shared with neighbor EV(s) based on hop count communication and with the remote administrator and far distance EV(s) through concerned Base Station. The embedded sensor nodes in EV(s) collect the machine-learned and CSE information from battery boxes and share this information with participating electric vehicles in the network. The data packets were generated randomly in the network to update the routing table of participating EV(s) based on distance, charge statistics, vehicle ID, and location information. The packet generation is set about 33 packets per second. Every participating EV broadcast a route update request after every 30 seconds in the network. The packet delivery ratio analysis was made during the experiment to overview the reliability of the proposed algorithm. The packet delivery ratio analysis observed for the proposed algorithm in the packet analyzer tool and individual EV dashboard screen, which were found quite consistent. The first analysis for PDR was made, when the EV(s) were in motion and they were communicated with each other through hop count selection in the network.

The results were evaluated for an individual EV by checking its route request messages and route reply messages. Similarly, the location of the communicated EV(s) was dynamically changed to verify the result statistics. Therefore, the process of communication was continuous to check the PDR result, when the base station was involved in the communication process (roaming). The message packets sent from source EV were assessed against response messages to overview the PDR of our proposed enhanced-DSDV routing protocol. The statistical analysis of our scheme for packet lost ratio is shown in figure 9, which were observed during the operational network from the packet analyzer tool, individual EV dashboard screen and remote administrator PC. Moreover, we have used packet analyzer at the BS(s) site to analyze traffic statistics for PDR. Similarly, we also used packet analyzer EV site with embedded sensor nodes to ensures the results statistics.

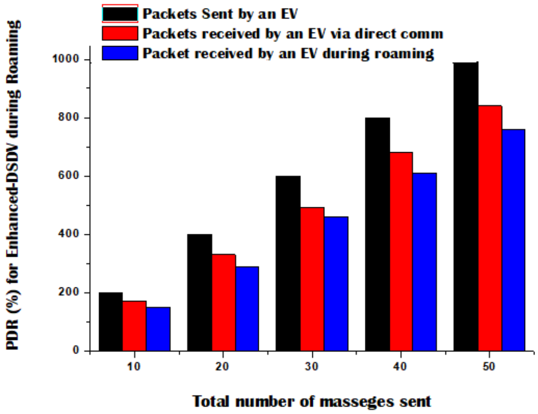

FIGURE 9. **Packet delivery ratio of our proposed enhanced-DSDV routing scheme during operational network.**

E. END-TO-END DELAY OF ENHANCED-DSDV ROUTING PROTOCOL

The proposed routing scheme of enhanced-DSDV routing protocol was also checked for end-to-end delay when the EV(s) were communicating with each other in the network. End to end delay is another very important aspect to be considered while designing new routing protocols or modifying the existing protocols. Therefore, in the proposed scheme the end to end delay of enhanced-DSDV routing protocol was checked during operation network, when the EV(s) were communicated through hop count information and as well when the BS was involved in the communication process. The results of end to delay was seen by initiating a route messages in the network. The participating EV(s) responded with their route reply messages, which contained EV-ID, distance, location, and charge information. In the proposed scheme, the distance metric was kept constant for an average time to evaluate the end to end delay accurately. The results statistics for end to end delay were seen in the individual EV dashboard and remote administrator screen with average time response. Moreover, a packet analyzer tool was also used to verify the accuracy of our proposed model based on end to end delay communication. During the result assessment packet analyzer mode was set to monitor the latency for an incoming

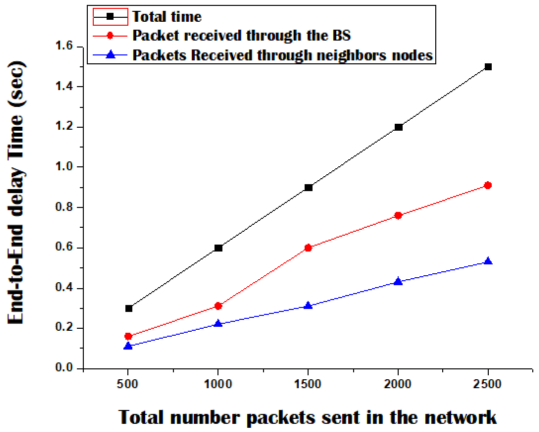

FIGURE 10. Statistical analysis of end-to-end delay of enhanced-DSDV routing protocol.

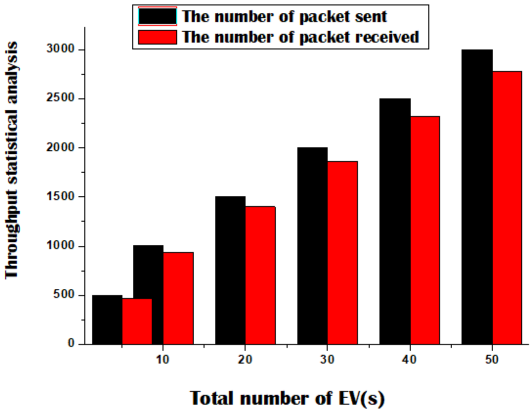

FIGURE 11. Graphical representation of average throughput statistics of the enhanced-DSDV routing protocol.

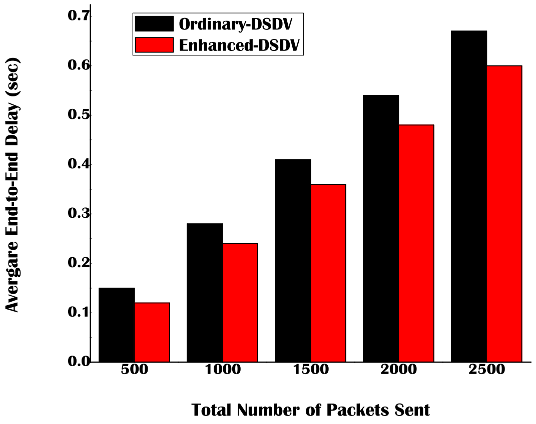

FIGURE 12. End-to-end results statistics of the enhanced-DSDV routing protocol with ordinary-DSDV routing protocol.

route request and reply message in the operational network. The end-to-end delay assessment continued to verify the average end to end delay during direct communication (with adjacent nodes) and as well as through base station, where the base station was involved in the communication process. The results captured for end-to-end delay from individual EV dashboard screen, packet analyzer, and remote administrator screen during operational network are shown in figure 10.

Figure 10 shows the delay statistic (time) for enhanced-DSDV routing protocol, when an EV communicate with other EV in the network through hop count information or via the BS in the network.

F. THROUGHPUT OF ENHANCED-DSDV ROUTING PROTOCOL

The enhanced-DSDV routing protocol was also evaluated for the average throughput of the network. The average throughput of the enhanced-DSDV routing protocol was evaluated during the operational network. During throughput result analysis, various route request messages from different EV(s) were generated for communication in the network to check traffic accommodation with positive reply messages. The throughput results statistic was seen at a different site (EVs) with a congested traffic environment to verify the reliability of enhanced-DSDV routing protocol. However, the results observed for throughput was quite significant in terms of managing network traffic. The packet analyzer was also used at different locations (sites) such as BS(s) to monitor the throughput of the proposed routing scheme. Likewise, the results captured during analysis for throughput at different BS(s) for proposed scheme in the packet analyzer are shown in figure 11.

G. END-TO-END DELAY RESULTS ANALYSIS OF ORDINARY-DSDV AND ENHANCED-DSDV ROUTING PROTOCOLS

The proposed enhanced-DSDV routing scheme is also evaluated for end to end delay with ordinary DSDV routing protocol to observe the performance metrics in terms of results. Although, ordinary DSDV routing protocol also follow hop count information to transmit data from source to destination. However, the modification made the in ordinary DSDV routing protocol in our enhanced-DSDV routing protocol shows improvement in the end to end delay statistical results, because during roaming from one BS to another BS, the proposed scheme showed consistency in time during communication process. Likewise, the ordinary DSDV routing protocol did not maintain the same time consistency, while roaming during communication process (movement of EVs). Therefore, the results captured for enhanced-DSDV routing protocol showed improvement over the ordinary DSDV routing protocol in terms time uniformity during communication processing or message exchange. The comparative results for aforestated protocols are shown in the following figure 12.

V. CONCLUSION

In this paper, we have proposed a hybrid scheme to enable DWC in EV(s) through the machine learning technique. In the proposed model, we interconnect all participating EV(s) through enhanced-DSDV routing protocol in the network topological infrastructure. Furthermore, CSE and embedded wireless nodes were used in each participating EV to assess the current state to charging, location, vehicle-ID, and the distance. The CSE continuously monitors the charging state of an EV and shares the capture data through an embedded wireless node. Variational auto-encoders algorithm of unsupervised machine learning technique was used to monitor the critical state of charging in an EV with coordination of CSE. In the proposed model, BS(s) were introduced in DSDV routing protocol to improve the latency, throughput, and packet lost ratio. The proposed model was implemented in real environment, where communication was conducted among the participated EV(s) to verify its reliability. Moreover, the administrator can easily manage the participating EV(s) from a remote location. Furthermore, a generator was used in each EV to establish a magnetic field. The magnetic field of two EV(s) makes an interference with each other, which is known as magnetic coupling. The magnetic coupling interface allows the paired EV(s) to transfer power wirelessly. The results of the proposed model were evaluated during charge transfers in static position as well as in motion that is up-to 5 KM/hours, which was found quite significant. The efficiency observed during charge transfer between paired EV(s) in a static position with 1.5-meter distance was about 89%, where the strength of MF was quite strong. The distance metrics were changed from 60 cm to 40 cm and 25 cm in the subsequent steps to verify the results. We have observed that once the distance between the paired EV(s) was changed, the power transfer rate was found 85 % and 82 % for the distance of 40 and 25 cm respectively. These experiments clarified that at a distance of 1.5 meter EV(s) is the most feasible distance where maximum power is transferred between the two EV(s). Moreover, the enhanced-DSDV routing protocol was evaluated for throughput, latency, and packet lost ratio during hop count communication as well as via BS connectivity. The results for communication metrics such as latency, packet lost ratio and end to end delay were quite significant. The additional property of our proposed model is that it is the first scheme, where every EV is capable to transfer power to another EV in the network. The implementation and maintenance of the proposed model is cheap with better results as compared to existing scheme.

In future, we are looking forward to extend the proposed model to a heterogeneous environment of EV, where all EV(s) will be connected in a network topological infrastructure. Moreover, every participating EV will be capable to transfer charge to another EV in the DWC fashion.

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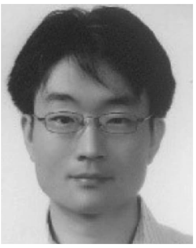

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