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Technical investigation on V2G, S2V, and V2I for next generation smart city planning

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ABSTRACT

The paper investigates a few of the major areas of the next generation technological advancement, “smart city planning concept”. The areas that the paper focuses are vehicle to grid (V2G), sun to vehicle (S2V), and vehicle to infrastructure (V2I). For the bi-directional crowd energy single entity concept, V2G and building to grid (B2G) are the primary parts of distributed renewable generation (DRG) under smart living. This research includes an in-depth overview of this three major areas. Next, the research conducts a case analysis of V2G, S2V, and V2I along with their possible limitations in order to find out the novel solutions for future development both for academia and industry levels. Lastly, few possible solutions have been proposed to minimize the limitations and to develop the existing system for future expansion.

1. Introduction

Through the path of development, human has craved for more comfort, which leads to the seeking of knowledge and technologies. The current strategy of that path is the smart planet, and to achieve the smart planet we need to ensure smarter cities. A smart city consists of smart computational technologies that help it to monitor all of its infrastructure and residents, deal with any kind of crisis, and come up with positive outcomes. Moreover, smart cities ensure the participation of smart residents to drive economy and governance by creativity and entrepreneurship. The term, smart city, is used analogously to the intelligent city, city of the future, etc. and their definitions are more or less similar. According to Komninos, intelligent cities are “territories with high capacity for learning and innovation, which are built in the creativity of their population, their institutions of knowledge creation, and their digital infrastructure for communications and knowledge management”. Whereas Hall defined a smart city as the city that monitors and integrate conditions of all of its critical infrastructure. According to International Business Machine (IBM), a smart city needs to be instrumented, interconnected, and intelligent. The focus of IBM to develop a smart city is to embed sensors and equipment in all sectors of life and form Internet of things (IoT) to control and monitor those equipment [1–5]. Since, the IoT and big data based smart city is the next generation concept, the energy sector of this newly developed research industry is still new and emerging. Building to grid (B2G), vehicle to grid (V2G), sun to vehicle (S2V), and vehicle to infrastructure (V2I) with the single entity bi-directional crowd energy flow concept are still very new. Most of the countries, government agencies, universities, and other research institutes and industries are conducting research

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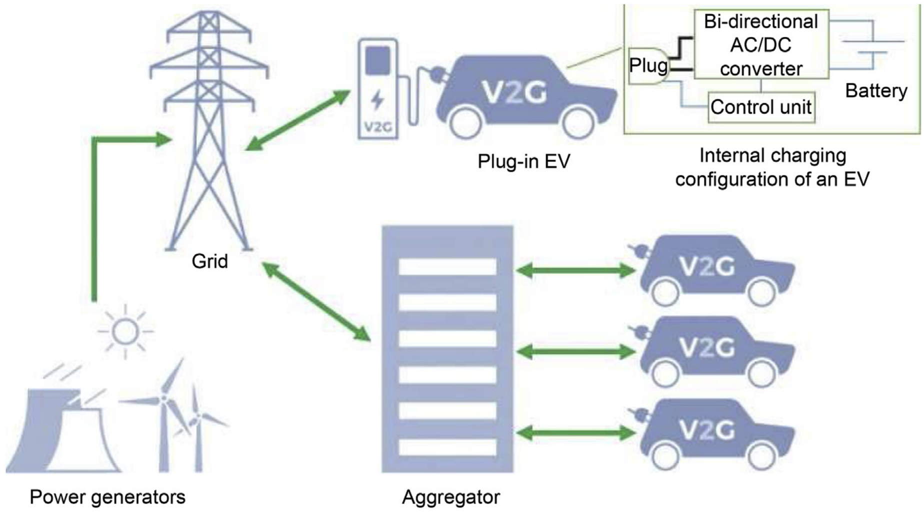

Fig. 1. V2G block diagram.

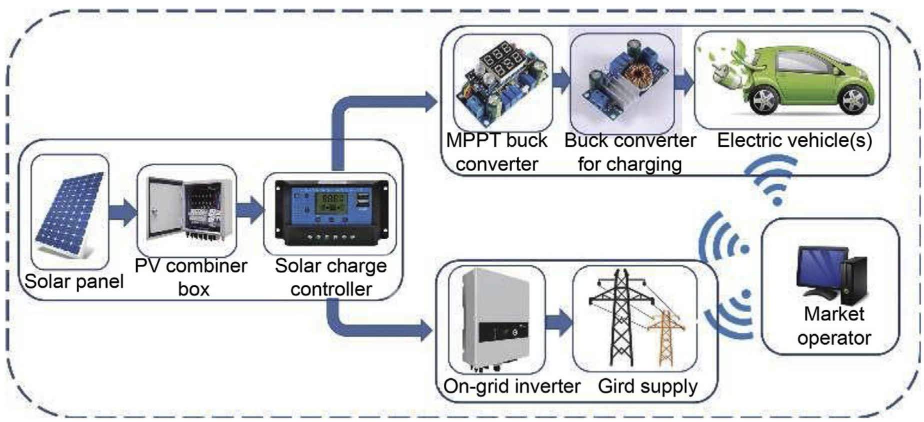

Fig. 2. S2V block diagram with smart grid concept.

in these areas in the experimental phase. A lack of systematic analyses of the research findings along with finding out the limitations and possible solutions is the major concern in this sector. This research tries to fill up the gap and tries to find the answer to the above mentioned issues. The planning of the next generation smart city includes the smart grid and IoT, which again relies on the implementation of technologies like V2G and B2G [4,6–9]. The concept of V2G emerged when Kempton et al. proposed to use the batteries of electric vehicles (EVs) as a power storage medium. They proposed to store electric energy at night time when the electricity price rate is low as well as the demand and then use those batteries to support the grid at day time when the electricity demand is high [10–12]. Currently, the V2G concept has evolved and EVs are not only charged by the grid, but also from renewable energy sources, majority of which are based on solar energy [13–16].

2. Overview of V2G, S2V, and V2I

2.1. V2G: vehicle to grid

V2G offers intelligent grid operation involving demand response (DR) services between EVs and the power grid. Here V2G refers to the transfer of power and relevant data between transportation and electrical grid systems enabling synergy between both, which is necessary for the implementation of smart city. Fig. 1 shows the possible block diagram of V2G set-up.

2.2. S2V: sun to vehicle

EVs that are presently being used worldwide need charging stations similar to the gas stations needed for fuel based vehicles. The process of charging EVs with the help of charging stations run by solar power with the aid of photovoltaic (PV) cells is known as S2V or

EV-PV charging [13–18]. Fig. 2 below shows the smart grid concept of S2V implementation. Though the idea of solar powered vehicles and its implementation are quite old, however the term, S2V, was primarily used by Birnie in Ref. [18], where he proposed that the daily commuters having EVs can get daytime charging from solar arrays installed in the parking lots. These solar arrays acting as the charging station for EVs can help to balance the electrical power flow and reduce the dependence on fossil fuel, thus reducing the carbon emission.

2.3. V2I: vehicle to infrastructure

One of the looming technologies in the field of communications and vehicular technologies is V2I communications. In V2I, the vehicles establish connections with the roadside units (RSUs) to exchange information. Due to the varying high speeds of the vehicle, such architecture tends to produce dynamic throughput. Some of the major issues addressed by the V2I technology are the amelioration of traffic congestion and road safety while reducing the effect of environments.

3. Overview theoretical concept vs. practical implementation

3.1. V2G

EVs could be maintained in small micro-grid configurations such as between several plug-in EVs or between EVs and buildings. On the other hand, the exchange of power can take place through aggregators between the group of EVs and the main grid.

The power flow can take place uni-directionally through controlled charging of EVs called V1G or G2V. It can flow bi-directionally between EVs and grid called V2G. In this paper, we are focusing on V2G and its implications. As the name implies, the uni-directional power flow of V1G needs only standard car chargers and does not increase EV battery cycling damage. Through the addition of charge controllers, the EV charging rate can be controlled, resulting in DR services such as recharging during off-peak hours. However, for extensive DR services, bi-directional V2G is necessary. In V2G, the bi-directional power flow is realized using chargers having AC-DC conversion for power factor correction and bi-directional DC-DC conversion for controlling the battery-charging rate.

V2G has the potential to benefit both the consumer and supplier of electricity. In the case of electric grid managers, V2G can provide power (active and reactive) management, back-up power supply, demand curve valley filling and load balancing, reduction of grid harmonics, and increase in the reliability of load forecasts among others. It also allows the reduction of load peaks or peak shaving, efficient employment of current generation capacity, decrease of grid expenditure, improvement of load characteristics, better grid frequency control, rapid blackout recovery, etc. Similarly, for energy policy makers, V2G can help in the reduction of CO_2 emissions, grid incorporation of sporadic renewable energy sources enabling climate change reduce, boosting of EV sales thereby allowing further reduction of greenhouse gases, etc. Comprehensive adoption of V2G can also help potential EV customers by allowing better charging infrastructure. The above-mentioned DR services can also provide monetary incentives for grid connected EV users [8].

V1G (G2V) enables grid supplementary services by employing a variable EV charging rate dependent on the power generation needs. This is managed by EV aggregators which act as intermediary bodies between the power grid and collection of EVs. These supplementary services allow EVs to act as distributed energy resources. The services include grid management through frequency regulation, appropriation of spinning reserve as backup for the unexpected power loss, reactive power compensation, etc. As an example, plug-in EVs offer a low cost alternative to large generators in frequency regulation since EVs can be power-cycled much more easily. These grid connected EVs can also provide easy reactive power support using their chargers' capacitors. It is also seen that EVs can provide valuable forecasting data for grid, transportation, and other related industries [19–25].

3.1.1. V2G limitations

Although V2G can help in the realization of a smart grid for a smart city, it has several challenges that need to be addressed before it becomes a viable option.

Most notably, EVs that take part in bi-directional power flow (V2G) will accrue more and deeper charge cycles compared with the only V1G or G2V case. Thus, battery deterioration will be more pronounced depending on the depth and frequency of the charging and discharging cycles [8]. The level of deterioration also depends on the type of battery used in EVs [25–29]. Battery degradation can happen in two different ways, namely in terms of capacity and power delivery which can be characterized using the above mentioned parameters including operating temperature, state of charge, capacity throughput, etc. [30]. In addition, a lack of battery leasing options means customers cannot take part in V2G without worrying about battery degradation [30,31].

V2G realization will require additional investment to deploy the smart grid and bi-directional charging capability [7]. Since V2G requires more battery cycles compared with V1G, it will result in greater AC-DC conversion losses [8].

Greater adoption of V2G necessitates an increase in the use of EVs, which will require more generation capacity [8].

EV customers who will take part in V2G may suffer from charge anxiety, which can limit V2G adoption. This refers to the stress of customers worrying about whether they can reach their destinations if prior to departure EVs took part in V2G functions [8].

Energy regulation policy needs to be worked out before EVs can take part in DR services [31].

Since V2G will require a smart grid for control and maintenance, there is an increased risk of cyber-attacks [8,31]. Furthermore, the smart grid will need to be robust for acceptable reliability of V2G control [32].

Manufacturing of EVs and batteries can have a significant environmental impact, which needs to be addressed [19].

Many of the above-mentioned effects have only been studied in theory while without proper experimental validation, thus further mitigation in practice may be required [33].

3.1.2. Current trend and practical case analysis of V2G

The authors in Refs. [34–36] discussed about the negative effect of unregulated charging of EVs on the grid and battery health. The authors gave a view on stabilizing the grid performance while using the solar as distributed renewables which in terms deal with the G2V efficiency [34]. Few constructive efforts have been stated in Ref. [35] as the future scope where V2G has been stated as the next generation advancements in crowd energy and smart city concept. The authors in Ref. [36] quantified the parameters that affect battery deterioration and grid supplementary services through EVs. Here the authors in Ref. [36] modelled charging of EVs and found that even modest 10% of unregulated EV charging can cause grid overload. This can be overcome by delaying the charging schedule to off-peak times when renewables are available. Although for emergencies, a certain minimum charge level can be maintained as necessary. In the case of battery life, lab tests were performed, which showed that by reducing the mean state of charge and overall charge transferred, battery health can be significantly improved. The study also showed that if controlled charging was maintained, then EVs that provide V2G services would not experience worse battery health outcomes.

In Ref. [37], the authors examined the effect of sporadic renewable energy sources on the stability of the EV chargers. The irregular nature of the voltage can cause distortions of the charger current, which in turn can damage it, negatively impact the battery health, and cause problems in metering accuracy. The authors proposed a reactive power method to improve the charging profile and later verified it using simulations. To address these issues the authors proposed a frequency multiplier circuit and a charging profile for enhanced power quality. The simulation showed that these steps would indeed help in the reduction of charger current distortion, reduction of device stresses, and elimination of voltage output variations.

The authors in Ref. [38] discussed the effect of emission management guideline on the V2G scheme for EVs. A genetic sorting algorithm was used to model the V2G scheme, where customers and EVs were to help in formulating the emission guideline, which was later verified through simulations. The paper [38] determined that EVs were effective in reducing emissions and at the same time could provide financial incentives for the users. However, this effect became less pronounced if overall greenhouse emissions were considered for plug-in EVs. It was observed that if the V2G emission guideline caused significant reductions in financial incentives for the users then there was less eagerness for users to switch from fossil fuel engines to EVs. This shows that guideline leniency is necessary to promote the emission reduction through V2G adoption.

In Ref. [39], the authors presented a novel EV charging-discharging method employing an inverter based on a synchronous machine and a three-phase bridge voltage controller. This allowed improved power quality for EVs and a repetitive controller to enable EV-grid voltage to closely follow a recommended value. The paper showed that EVs using the proposed inverter-controller scheme managed to provide neat and balanced voltage to the grid. This in turn provided an improved charging-discharging current profile for EVs. In case of users, safety and dependability of the electric supply are increased whereas, in regards to the grid, efficiency and effectiveness were increased.

The authors in Ref. [40] discussed the security and privacy implications of V2G grid communications. A novel communications scheme was proposed to address the cyber security, privacy, and liability without depending on the third party solutions. The presented model employed a group signature process specially formulated for V2G applications. The group manager functions were divided into two separate EV aggregators in the system to ensure user privacy and responsibility. This model was then tested experimentally for feasibility. The tests showed that the presented scheme was capable of maintaining user privacy for V2G applications through source authentication, message coherence, resistance to common cyber-attacks, data secrecy, and user liability.

In Ref. [41] the authors presented a novel V2G aggregator-scheduling scheme for balanced EV customer satisfaction in conjunction with aggregator profits for grid frequency regulation. A controller was designed to determine the frequency management timetable taking into account EV battery state of charge, average trip distance, and grid frequency regulation needs, and minimize the depth of discharge. The presented scheme was verified through simulations. The results showed that the proposed scheme ensured acceptable aggregator profit margins while keeping EV battery state of charge and EV range at reasonable levels.

The authors in Ref. [42] discussed about renewable wind energy integration for the UK power grid and a simulated power grid. The study considered three scenarios: One with only internal combustion engines, one with EVs having only V1G, and lastly EVs with V2G. For the UK grid study, it was shown that V2G EVs had the best results when considering the reduction of greenhouse gases and higher assimilation of renewable wind energy since EVs could act as adjustable energy storage. For the simulated grid, again V2G EVs allowed more self-sufficiency in terms of electricity production compared with the other cases.

In Ref. [43] the authors designed a novel bi-directional converter for V2G chargers employing resonance. This circuit ensured soft switching thereby reducing electromagnetic interference so that high frequency operation can be realized. This in turn allowed the magnetic and capacitive parts of the circuit to be shrunk in size. For this purpose, an equivalent model was used to determine relevant parameters for a 3.3 kW converter. The design was experimentally verified showing that the peak efficiency was within acceptable levels.

3.1.3. V2G: proposed solution and future plan

In Ref. [43] the authors designed a novel bi-directional converter for V2G chargers employing resonance. This circuit ensured soft switching thereby reducing electromagnetic interference so that high frequency operation could be realized. This in turn allowed the magnetic to counteract EV battery deterioration due to the increased charging cycles from V2G operation, controlled charging regulation could be devised to minimize a negative impact on battery health while keeping profit margins and service levels at acceptable levels [8,36,37,41]. While choosing battery types for V2G operation, battery costs should be taken into account because expensive batteries may not be economically viable for the repeated charging cycles needed for proper V2G operation [29].

Proper energy policies are necessary to incentivize the adoption of V2G. The funds could be taken from initiatives focusing on the integration of renewables and reduction of emissions among others [38]. Appropriate steps should also be taken so that non-experts become aware of the potential of V2G, since this can be a significant barrier for its adoption, at least in the early stages [44].

Charge anxiety for EV users can be overcome to a certain extent through properly spacing EV charging stations in areas taking part in V2G operation [8].

While considering the implementation of V2G and the overall environmental cost of the increased electricity production, EV manufacturing should be considered along with economic viability to determine whether it is justified for the specific scenario [19].

Further research is necessary involving pilot projects and experimental implementation for proper smart city adoption of V2G since simulations necessitate assumptions, which may not hold in real life.

3.2. S2V

The feasibility of S2V depends on factors like the regional solar irradiance and its variation with seasons, the probable efficiency of PV cells, the population density and average distance a commuter transits, the nominal area for a usual parking space size, and the storage capacity of an EV. The platform S2V is supposed to reduce the energy demand on the grid and use EV batteries as energy storage as well as minimizing the excessive PV integration in the grid, and eventually ease the path to implement full-scale V2G where EVs will act as a spinning reserve. The practical implementation of S2V is still on a nutshell and still needs a long way to go. However, with so many practical experiments and statistical simulations, backed up by numerous patents in the fields of S2V, we can expect the large-scale implementation of S2V very soon. Here in this article, we will have an overview of some of the analysis done both from the viewpoint of optimizing S2V and feasibility of S2V with practical data collected from different parts of the world [17,18,20].

In Ref. [17], the authors used practical data to find the feasibility of charging EVs at workplaces in the Netherlands. Their major findings are: An optimal tilt for PV panels is achieved; the PV array can be oversized with respect to the PV power converter up to a certain limit depending on the meteorological data; dynamic charging is a better approach while charging EVs; local battery storage could not remove the grid dependency of EVs in the Netherlands. In another work [21] of the same authors, they have discussed the economic and environmental benefits of EV-PV charging stations for workplaces in the Netherlands. They have proved with simulations and statistical data that EVs powered by solar energy can reduce the fuel cost by 1500 euro and the CO_2 emission by 770 kg/car/year. Similar to the study in the Netherlands, another study was conducted in Portugal [22] and the study found that the short daily window of power generation from PV cannot be used properly even with the charging of EVs and wastes most of the time. Their studies suggested that the improvement of technologies and implementing load shifting may elevate the situation. In Ref. [20], the economic benefits of S2V were analyzed for Columbus and Los Angeles with the case scenario that charging stations are workplace parking garages. These two places were chosen for the analysis as their solar influx patterns and financial structures are totally different. For both cases, it was found that workplace charging can be beneficial for both parties, the EV owner and the station owner. With all the benefits of workplace charging of EV as described in Refs. [17,20,21], and [23], it is almost concluded that it can be the gateway for the future transportation system. However, the work of [24] reminds us not to take any decision hastily, while the article tells us that the best case scenario for any EV is to charge at home only with level 1 charging. The article suggests EV users to be careful about charging in different levels of voltages as it will degrade the battery's performance and durability.

The optimization of the charging stations was investigated thoroughly by researchers worldwide and to get a glimpse of it, some of the articles are [23,25], and [26] and with prototype patents as [27,28]. In Ref. [23], they proposed a DC voltage sensing control strategy, where the voltage decides the mode of operation and the direction of the power flow for the charging station. The change of DC link voltage with respect to the change in solar radiance is simple and merged with the demand management algorithm which is the pathway to efficient energy transmission. An interesting subject namely, smart charging, was discussed in Ref. [25]. The aim of smart charging is not to get the maximum solar power but to maximize the profit by manipulating the demand and variable price rate of electricity. At the time of high demand, the market operators increase the price of electricity, now if at that time solar power can be used to support the electricity demand then a possible profit may be achievable. The authors showed that for the cases of the Netherlands and Texas, the annual EV charging costs decreased significantly. Another study similar to the previous was done in Ref. [26] to optimize the use of EV-PV charging. They have proposed a use-of-time tariff where the customers charging pattern will be known throughout the network, thus the EV charging load curve will be available and the electricity rate can be modified accordingly with respect to time. Their proposed platform attained minimum costs with maximum utilization of PV cells and benefitted both the customer and operator financially.

3.2.1. S2V limitations

The limitations that S2V is currently facing can be divided into three major parts. The first one is related to the harvesting of energy, then comes the battery technology, and lastly the communications between EV, grid, and charging stations. Work on renewable energy harvesting or extraction is being done excessively nowadays as renewable energy is affluent and purest among all the energy sources. Presently solar energy is the most widely used renewable energy but the maximum efficiency of PV cells that has been achieved till now is just above 20% [34,35]. Battery degradation and battery storage capacity are the second major problems that hinder the pave way of S2V. Current technologies cannot provide enough storage capacity for EV to store the output power of a charging station even on a winter's day. Also, though the durability of the battery has increased significantly, still the degradation due to various charging issues is yet to be solved apart from the environmental factors. Lastly, the communications between the grid, charging station, and vehicle are going to play a vital role in S2V implementation. Such as EVs daily load curve, hourly solar radiation considering weather impacts, intelligent metering, and information control that is aware of battery capacity and state of charge, these are still at the beginning level and need proper strategic development. Moreover, the PV panel installation and maintenance costs need to be checked if possible [13,17,20,21,23,34,35].

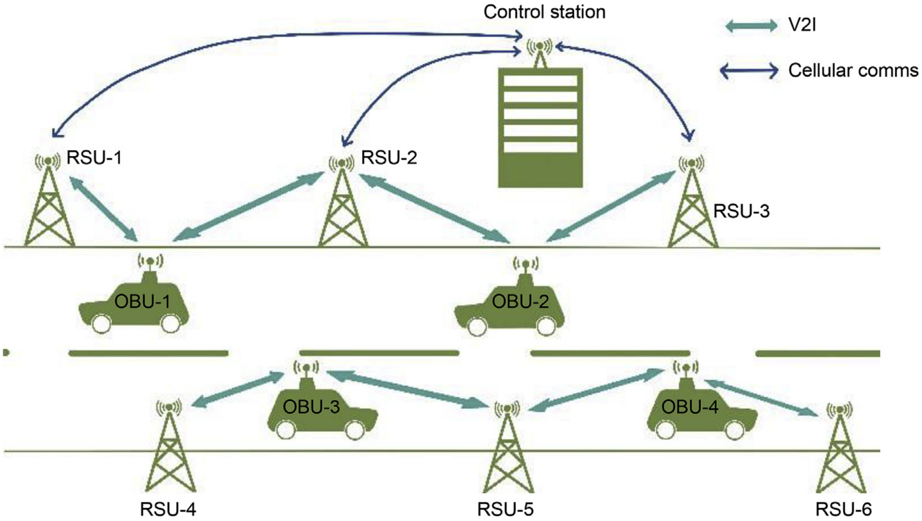

Fig. 3. V2I block diagram.

3.2.2. S2V: proposed solution and future platform

At present, the implementation ideas of S2V are well-developed and the execution is needed to be done. Some of the features that the S2V platform will have are discussed briefly as follows [13,17,20–22].

3.2.2.1. Dynamic charging or load shifting. EVs cannot be charged constantly from the PV cells due to the Gaussian like distribution of the solar irradiance throughout the day, with the distribution peak at noon. Thus research indicates that it is efficient to charge as more EVs as possible during the noon time to extract the most out of the solar panels. Also, due to this variation of solar power with time, it is also convenient to store energy with backup batteries which might be usable later at night. Dynamic charging or load shifting is the process where EVs are charged when the availability of power is high or the demand is low and may act as a source of power at the time of high demand and the unavailability of energy sources. Research indicates that varying the charging rates may be implemented to aid the process of dynamic charging. With low charging rates at noon and high charging rates at night, the EV owners are most likely to charge their EVs around noon. These EV owners can also be monetarily benefitted if they supply the excess energy stored in their EVs to the grid at the time of high demand with higher electricity rates.

3.2.2.2. Co-ordinated smart charging, discharging, and metering. The charging stations need the facility of smart metering to implement dynamic charging. The stations need to maintain a variable rate for the charging of EVs and a smart meter having access to the data like irradiance, current demand, forecasted demand, etc. is needed for that purpose. Smart meters and sensors at charging stations can monitor and communicate with the control center through an intelligent network. With the help of smart meters which have information about the battery capacity, the charging process of EVs can combine renewable energy with EV and the grid efficiently. To ensure smart metering, coordination is necessary between the grid operator, market operator, and EV owners.

3.2.2.3. Smart charging. The target of smart charging is to provide support when it is most needed. With the help of the data analysis and communications networks, an optimum solution can be provided for which the solar charging stations will generate maximum power at the time of peak demand. Though work is being done in this field, but still there are many factors to analyze.

3.2.2.4. Implementation of carbon tax. Though this is not a feature of S2V, however, the carbon tax people will be encouraged to use greener energy and thus ensure minimum or no harm to the environment. Already a few countries have started the procedure to implement the carbon tax where any person or entity has to pay a price for the carbon emission he or she is responsible for.

3.3. V2I

In this architecture, only the global server requires Internet connectivity, where the data are processed and analyzed accordingly. The global server, with the Internet facility, manages all services and consists of a database to store all information gathered from moving vehicles. The vehicles are capable of extracting information in real time on the environmental condition and vehicles' status to be systematically fed back to the global server. This is done primarily with an on-board unit (OBU) which is mounted with cameras and embeds sensors within or on the vehicle itself. Fig. 3 illustrates the block diagram of a typical V2I set-up.

The wireless IEEE 802.11p standard is used to implement the physical (PHY) layer of V2I. The IEEE standard utilizes orthogonal frequency division multiplexing (OFDM) which is able to withstand against multichannel fading. OBU may choose from 2G, 3G, 4G, or WiFi to establish the best connectivity during low traffic areas.

3.3.1. Limitations of implementing V2I

The communications via V2I do come with a number of limitations which are listed below.

a) The impracticality of dense placement of RSUs around the city.
b) Due to the dynamic nature of the connection in V2I, throughput varies over a large range.
c) The opportunistic nature of the connectivity between the vehicle and infrastructure renders the architecture unreliable in many situations.
d) The path loss due to the Doppler shift.
e) The uniformity of implementation of V2I in most vehicles around the city is required otherwise it may lead to sparse connectivity.
f) Sever security challenges exist in V2I communications: i) Proper authentication requirement to access the link between RSU and the vehicle; ii) protection against the false and corrupted message to uphold the integrity of the information gathered; iii) to make the resource available to the authorized personnel without any hassle.

3.3.2. Current trend of V2I

Japan has been developing driving safety support systems (DSSSs) under universal traffic management society to warn drivers about imminent road hazards [45]. The potency of DSSSs based on dedicated short-range communications (DSRC) and infrared driven V2I has been tested and proven at road crossings.

The IntelliDrive initiative of the U.S. Department of Transportation (USDOT) has developed safety applications which are able to caution drivers of probable accident situations or locations by issuing visual or vocal warning messages [46]. Based on IEEE 1609 and IEEE 802.11p communications standards, wireless access in vehicular environments (WAVE) is used to accomplish two-way connectivity between vehicles and infrastructure [47].

The cooperative vehicle infrastructure systems project in Europe is working to implement uninterrupted and unambiguous communications between vehicles and infrastructure using 2G, 3G, infrared, WiFi, or WAVE networks [48].

Altalib et al. showed an improved bit error (BER) performance and a saving in transmitted power by the latest OFDM index modulation known as OFDM-IMA for use in the V2I environment [49].

In Ref. [50], the authors proposed a scheduled plan using a database from V2I or V2V for the fuel consumption of vehicles, taking into account air-condition usage and traffic density.

By selecting the communications ranges of 250 m and 100 m and data rates of 4 Mb/s and 10 Mb/s for V2V and V2I, respectively, the authors in Ref. [51] calculated the average time for the delivery of large multimedia messages. The calculations were based on the one-way highway model under low traffic conditions where the placement density of RSUs and message size may be varied.

Du et al. devised an algorithm using V2I data namely candidate link and its corresponding weight to identify the position of a vehicle on maps [52]. A series of tests verified that the positioning accuracy was in excess of 95% and hence proven to be feasible for practical applications.

Miller suggested a new hybrid vehicle to vehicle to infrastructure (V2V2I) architecture combining the fault endurance capability of V2V in a dispersed environment and quick, accurate response to inquiries of V2I communications. The author developed an algorithm to identify a super vehicle, a vehicle which accepts data from all other vehicles to be transmitted to a central database. The demand for the bandwidth from the server was thereby reduced [53].

4. Current projects of V2G, S2V, and V2I

4.1. Fill Nuvve battery storage system

This project demonstrated that recycled EV batteries could be used for V2G frequency regulation, which could help independent grid service operators. The 220 kW project was located in Delaware, USA and carried out by Nuvve in partnership with Pennsylvania, Jersey, Maryland (PJM), Customized Energy Solutions (CES), Electric- Vehicle Grid (EVGRID), and the University of Delaware between September 2017 and December 2018 [54].

4.2. EDF Energy and Nuvve

EDF Energy and Nuvve plan to install 1500 V2G chargers in the UK, supplying up to 15 MW of supplemental energy capacity [55].

4.3. GridMotion, PSA

This project aims to demonstrate economic benefits in regards to the reduced EV user electric bill without affecting the range through smart scheduling of EV charging and discharging. For this purpose 50 V1G chargers were installed at residents around France and 15 V2G charging stations in Paris area for services such as grid balancing, demand charge, EV charge scheduling, etc. between 2017 and 2020 [56].

4.4. Network impact project, northern power grid

The goal of this project is to ascertain the infrastructure necessary for V2G in the northern power grid of the UK in partnership with Newcastle University. For this purpose, 19 V2G stations were installed at different grid depots and commercial locations starting from

Fig. 4. Digital surveillance system, a part of the Smart City Planning by Ezzy Automation, Bangladesh Computer Council (BCC) and associates.

April 2018 [57].

4.5. Across continent EV services (ACES)

This project aims to determine the overall effect of large scale V2G integration in Bornholm, Denmark from April 2017 to March 2020 in partnership with Bornholms Energi & Forsyning, Technical University of Denmark (DTU) and Nissan. For this purpose, 50 V2G stations and Nissan EVs are being used to study V2G charging, grid services, etc. [58].

4.6. Ministry of economy, trade and industry (METI) and Nuvve

The goal of this collaboration was to promote the adoption of EVs in Tokyo, Japan through the installation of bi-directional chargers for services such as V2G, frequency regulation, etc. between November 2018 and 2021, in partnership with Chubu Electric Power and Toyota Tsusho [59].

4.7. ENGIE

In this project ENGIE, Hitachi and Mitsubishi demonstrated the potential for EVs to act as energy storage for office buildings in Zaandam, Netherlands. For this purpose Hitachi's vehicle to everything (V2X) charger was installed around March 2018, which can transfer power between EV and the grid along with the ability to interface directly with solar panels [60].

4.8. Digital surveillance framework for security in Sylhet, Bangladesh by Ezzy Automation and associates

As a part of the Smart City Planning and Vision 2041, every city in Bangladesh will be covered under digital surveillance, a smart control monitoring interface in which the interface will take snapshots of the vehicle in different places, consequently the intelligence will get the feedback of the vehicle position in real time. In this way, the vehicle will automatically be under control of monitoring infrastructure which in result strengthens the entire security system of the country. On July 27, 2019, the Central Monitoring System Room of the Sylhet Digital Surveillance System was inaugurated by the Honourable State Minister of Information and Communication Technology, Mr. Zunaid Ahmed Palak, as shown in Fig. 4 [61].

5. Summary and conclusion

To recapitulate, this research makes a significant contribution to the newly developed smart city concept. The next generation technologies, such as S2V, V2G, and V2I, and the integral parts of the smart city have been explained in detail with an authentic source from highly cited references.

The current trend of renewable energy is going towards the single entity crowd energy concept. Previously, lot of research has been conducted to generate electricity with a low speed for wind energy followed by a discovery of a hybrid interface of wind and solar capable of generating voltage for each of the renewable side. The hybrid renewable energy of wind and solar is going to be implemented into distributed renewable energy for the next generation smart city planning concept whereas single entity crowd energy will take the leading role. A real-time smart monitoring interface will be developed for the smart monitoring interface to make people's life userfriendly [62–67]. S2V and V2G are supposed to be the parts of the next generation smart city technological enhancements. Bangladesh is taking revolutionary steps in the Smart City Planning through the Ministry of Information and Communication Technology (ICT) and Ministry of Power Energy and Mineral Resources (MPEMR) where V2I, B2G, V2G, and S2I will play major roles.

This research finds the research gap between combining the technical details, case analysis, current trends, and future platforms. After providing the detailed technical information, the research discusses the possible limitations and also proposes future solutions. The novelty of this research is to find the limitations after analyzing the current situation of these three major areas of smart city research and at the same time propose the solutions for the future development.

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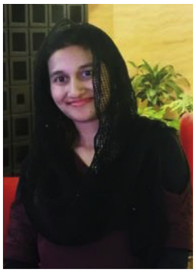

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