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An Analytical Review of SMART GRID Applications in VANET

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Abstract— Growing concerns about the reliability, efficiency, sustainability ad economics in production and distribution of electricity is driving an advancement from traditional electric power grid in the direction of smart grid. A chief smart grid enabler is two-way communications through the power system depending on which an innovative info system can make best decisions on operation of power systems. There exist many challenges related to power system planning and operations as EV are the main machines used in smart grid. Coordinated charging gives well-organized plans for the electrical vehicles to attain or achieve a good energy utilization which leads to less load on the electric system. Though, planning and designing an effective charging system to direct EV to nearby charging stations for efficient energy usage is a challenging task. In this paper, study and analysis on the smart grid technology is done. The role of vehicular ad-hoc network is to support real time communication in smart grid with the use of road side units and collecting the information of moving EVs for dispatching decision of charging. Cognitive radio is also illustrated which helps in reliable, efficient and robust communication in smart grid. The discussion of power flow structure in the network and the charging model through which the decision and action of charging of the EVs on the route is taken is briefly illustrated.

Keywords—Electriical vehicle (EV); Internet protocol (IP); Internet service provider (ISP); Road side unit (RSU); Vehicle to vehicle (V2V); Vehicle to grid (V2G), Cognitive radio (CR).

I. INTRODUCTION

The global change in climate and fast growing population over the last decades have produced increasing demands for rich, sustainable and clean electric energy on the universal basis. Though, in many countries the energy demands are increasing leads to heavy load on already over aged, overstressed and fragile infrastructure of electricity.

The smart grid is grid of clever devices which consist of variety of operational and measures of energy such as smart appliances, smart meters, energy efficient resources and renewable energy resources. The main and important aspects of smart grid are electronic power conditioning, controlling the production and distribution of electricity. It is basically defined as the electrical broadcast and distributed system which use digital information and the technology is controlled to improve its security, reliability and efficiency. The technologies used in smart grid are state estimation which improve the fault detection and permit the network to be self-healed without any interference of technicians. Hence, full reliable supply of electricity is achieved and reduction of vulnerability to attack or natural disaster.

Smart Grids are described by a firm assimilation between a flexible and protected data communication network with innovative management procedures that monitor and handle electric power systems. These progressive techniques are based on the sensors and actuators deployed in producing, transmitting and issuing electrical power which connect with data network to give clients set of services or applications range from control, automation and distribution to online energy costs verification. As communication networks play an important role in smart grid smart grid environment, proper designing and implementation is needed so that every function of the Smart Grid will be performed practical. One significant facet is quality of service (QoS) management. Thus, it is vital to plan mechanisms which can ensure the satisfaction of QoS requirements. Study has already revealed several solutions and have well-defined standards to design and govern conventional data communication networks that are usually devoted for the transmission of multimedia data over internet [1].

Nevertheless, emerging Smart Grid requirements vary substantially from today's modern technology internet. For ensuring QoS requirements, customary power systems use links such as dedicated links which is based on the standards like IEC 61850 or sometime take the proposed solutions of existing literature. But, these existing solutions are not realistic for the large size of data transmitted by the applications in the smart grid as the old or traditional power system were geared up with slow transmission speed [2].

Globally, every new technology or new innovation coming in market is equipped with sensors an actuators which make them smarter. These small devices embedded make every single appliance

were top-down, histotric experience based operation were there.

Eletrical vehicle i.e EV is an important constituent of sustainable and environmental friendly transportation systems and have received extensive response in several nations across the world. Instead of gasoline these vehicles are fueled by electricity equivalent to a transmitting device such as cell phone [3].

Benefits of smart grid:

- Centralized and distributed genration of power.
- Renewable power geneartion which is volatile.
- Power flow is multidirectional.
- Flexibility in loads demand.
- Real time data based operations.

Whereas in traditional grid, the power generation mechanism were centarlized and one directional, planning of the operatio and have large potential to save huge amount of money over the life time of vehicles [4]. As the conventional energy resources are used there is less emission of green house gases which leas to less polltion in environment. The emission of energy in transport sector will cut by 70% [5] .

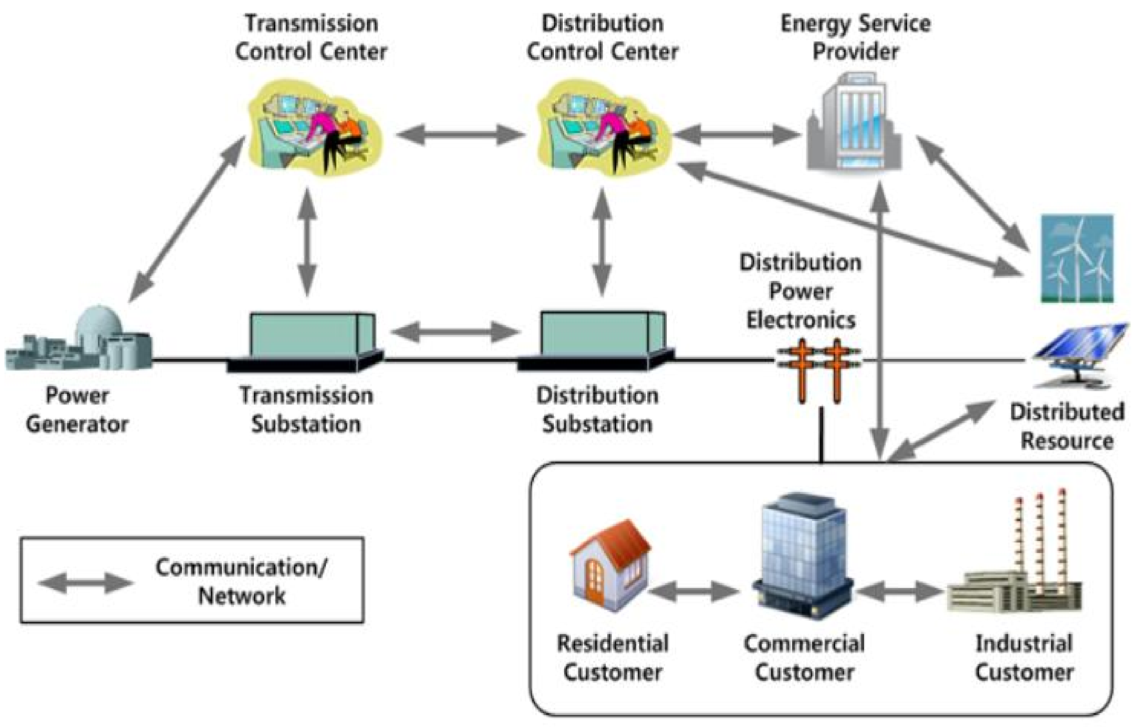

Fig .1 Smart grid architecture

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1.1SMART GRID

IT is a modern electrical system which consist of communication sensors, computers and automation to improve the reliability, efficiency, flexibility and security of the electricity system. It offers the opportunity to choose the facility to control the use of electricity. A smart grid comprises of different energy resources which are dispersed and in addition accommodate the charging of electric vehicle. The whole the devices, smart metering and other power devices in the network are connected to each other to facilitate different operations [6] .

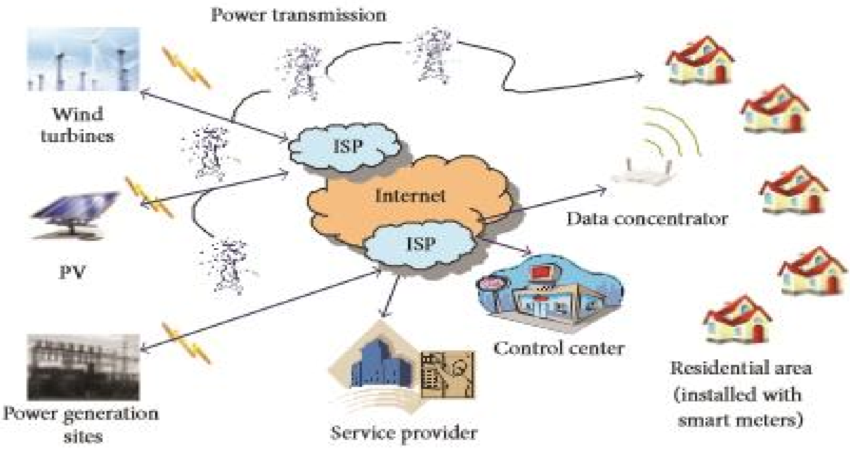

Fig.2 Communication architecture in smart grid [6]

1.2 Role of VANET in Smart Grid

Electrical vehicles are vehicles which work through electricity. Many problems arise in the EV in transportation system like charging problem, heavy loads etc. We need to focus on the vehicle information to help designing and establishing the effective coordinated strategy of EV charging. The main objective is to improve the utilization of energy.

The main work of VANET is to obtain the real time information the EV needed by the EV charging strategy. VANET is purposely designed for exchange of information among mobile vehicles (electric vehicles) and RSUs (road-side units) in a multi-hop environment. VANETs can easily provide the needed real-time information through vehicle-to-vehicle (V2V) which can be short range, vehicle to-RSU (V2R) communication. This makes vehicle information gathering cheaper and quicker in comparison to other networks like cellular networks and Wi-Fi etc [7] .

More prominently, road side unit (RSU) in vehicular ad-hoc network can impressively improve the timeliness of data gathering and distribution which let it perform synchronized charging schemes for a cluster of moving vehicles. Thus, VANETs are combined into smart grid to gather the real-time info of EVs in network which constantly move and broadcast the charging decisions. Moreover, as the moving EVs still do energy consumption while waiting for charging decision, the transmission delay for exchange of information cause extra travel cost for EVs in VANETs [8,9] .

Now the question arises after the collection of information about mobile EVs, how to do mobility-aware synchronized charging of EV for improving utilization of energy and reducing in travel cost.

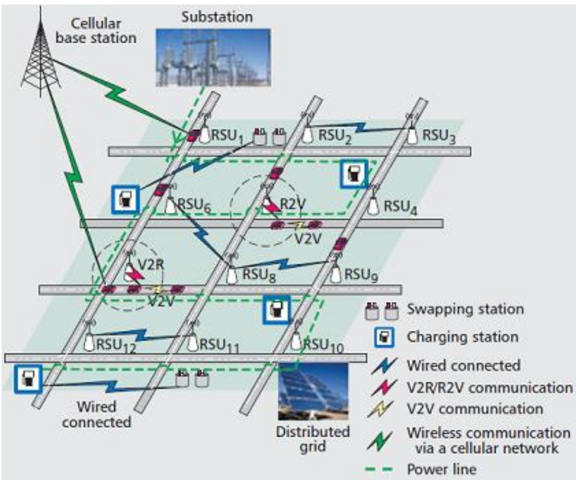

Fig.3 VANET in Smart Grid [12]

The above figure 1 describes the components of the of VANET in smart grid which consist of p

ower distribution system, charging stations that can be parking lots, traffic server , moving EVs , and Road side units (RSUs) beside the road. The central power distribution system supplies the energy to the whole network via power feeders.

1.3 Cognitive radio in smart grid

Cognitive radio network and VANET are the developing concepts in the wireless networking. The knowledge of the operational geographical environment is given to the cognitive radio to control and manage the sharing of spectrum between the authorized and unauthorized users whereas VANET passes the emergency safety messages across the EVs in smart grid to guarantee the safety of users on the pathway. The main purpose of employing the cognitive radio in the VANET to confirm efficient spectrum use and it also support efficient deployment of VANET [9].

There are many challenges encountered such as unplanned decrease and increase in the users of spectrum, VANET's unpredictable nature, changing interference, moving of EV's rapidly in the environment, security, assignment of priority and packet scheduling in the cognitive VANET environment [9]. The main key challenge of cognitive radio network in VANET is to deal with moving EVs under changing channel conditions which fairly sharing spectrum among the network nodes.

Cognitive radio also known as IEEE 802.22, give access to unauthorized users or clients to spectrum that is not used by the licensed users. It has the capability to sense the unused spectrum, give them to the unauthorized users and then again vacate it on the arrival of licensed user. The band which are used by IEEE 802.22 are UHF/VHF between 54 to 862 MHz [10].

There are many aspects in using the cognitive radio in smart grid communication system.

1. Technical viewpoint: The usage of cognitive radio is to handle the technical challenges in smart grid which are as follows:

- The main application of cognitive radio is to manage the spectrum scarcity problem in wireless communication.
- It eliminates the spectrum congestion which is the chief reason of applying the cognitive radio in smart grid [12].
- Large scale data transmission is supported by the cognitive radio by utilizing huge parts of spectrum.
- A mobile vehicles is low-power and low-cost device which is designed to work for several years so energy saving is extremely needed. Cognitive radio have power of adjusting the power of transmission based on operating environment which leads to energy saving and less spectrum is used. This type of adaptive functionality of cognitive radio make better for the future smart grid [11].
- By cognitive radios, machines are able to quickly shift among diverse wireless modes, hence reduce the interference with the external radio environment or the machine in the smart grid.
- As the EVs in the mart grid comprises of lot of services which may cause diversity in the protocols of the network and formats of data. The cognitive ability in smart grid is useful I dealing with the heterogeneity of machine and protocol.

2. Application viewpoint:

- The in-built merit of cognitive radio enables dynamic access to the additional spectrum like in TV bands cognitive communication for distribution and sharing of multimedia becomes encouraging.
- In future, the intelligent road is cognitive in a way that it can sense, listen, think and act. Intelligent sensors and communications devices on road surface enable these type of cognition capability which makes all the roads interlinked ton each other. This make the operators in the transport sectors intelligent and interlinked in a way to improve road traffic efficiency and safety [13].
- The use of CR in smart grid possibly increases utilization of spectrum and communication capabilities so that huge scale data transmissions can be done. Moreover, for smart meters which has comparatively small data volumes, cognitive radio has benefit of saving energy to support greener power grids [14, 16].

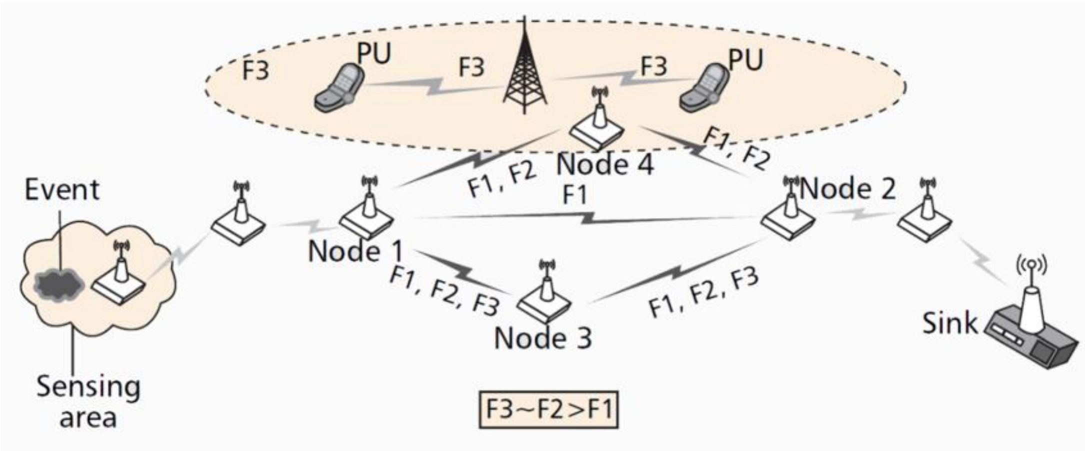

Fig.4 Cognitive Radio in Smart Grid

1.4 Power flow in smart grid

Power flow on feeders (buses) need to be considered when we implement the charging control on EVs. Assume to abstract the power system from the model of smart grid as shown in fig.3 that is now a one-line diagram with many buses. The system abstracted has 12 buses with an equivalent power model. Here N define the number of buses in the system with the count of 12 [15].

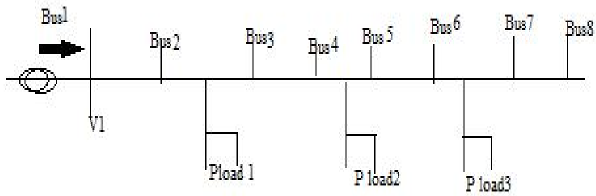

Fig. 5 Power system model

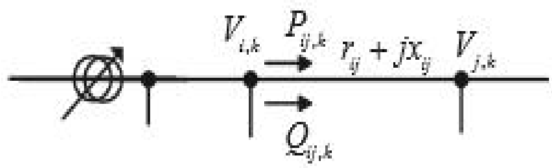

Fig. 6 Power Flow Description [3]

The generation bus i.e. *Bus_1* inject power to the system. But other buses only have load on them. The EV charging stations are at location of load buses in the network such as *Bus_3, Bus_6, and Bus8* respectively. Assumption is done that every charging station is connected to smart grid A.C connection [17].

The voltage of 2 nearby buses in the time instance *k*,

$$V_{i,k} - V_{j,k} = P_{i\ ,k} \cdot r_i \ +/Q_{i\ ,k} \cdot x_i \qquad [1]$$

In equation 1,

$P_{i\ ,k}$ = active power flow

$Q_{i\ ,k}$= reactive power flow

From the *Bus_i* and *Bus_j* in the interval *k*

Impedance of feeder line= $r_{ij} + jx_{ij}$

The main constraint of the distribution system operation is that the voltages of buses must be of particular range [18].

1.5 Charging model in smart grid

The movement or motion of every EV can be considered by two arbitrary variables (V, D). At this juncture, V signifies the velocity of vehicle receiving two values that are lower velocity v_l and a higher velocity v_h. The state transition rate is 1 D. Under the Markova chain model, a vehicle originally selects v_l or v_h, after some time interval that is exponentially distributed with mean of D, the velocity alters to v_l or v_h. The model can be opened to describe the genuine driving activities of individuals such as driver generally drives at a persistent velocity for a particular period and after that changes to high or low velocity on the basis of road conditions [19, 20].

When the EV need to be charged the charging load of EV,

1. v (ϵ V) at *Busj* in time interval k , $P\ h_{v,j,k}$, should be in range of

$$0 \leq P\ h_{v,j,k} \leq P\ h^{m}_{v,j,k} \quad [2]$$

In the equation 2, $P\ h^{m}_{v,j,k}$ is previously define d charging load assured of $P\ h_{v,j,k}$.

In EV is the v does not get charged in the time interval k then $x_{v,j,k}$ becomes 0. At that time the load in charging of EV in time interval *k 0.*

$$\frac{P_{v,j,k}}{P^{m}_{v,j,k}} \leq x_{v,j,k} \quad [3]$$

II. RELATED WORK

Adrian E. Coronado Mondragon, presented a network platform for smart grid and intelligent transport system using the LEACH algorithm. Due to use of wireless network in the smart grid the bandwidth is reused, better utilization of resource and better power management and control is there.

YAN ZHANG, has discussed the Vehicle to grid network which help the smart grid in energy saving. The architecture of V2g has been presented. In addition to that different security challenges in communication between vehicles to grid has been also described. After that authentication solution for this communication has been clearly defined and at last author described distinct pen issues for V2G communication networks.

Miao Wang, proposed a mobility aware coordinating charging plan for moving EVs. The energy utilization of the EVs is decreased by this method. For evaluating the performance of the proposed method, in VISSIM a realistic scenario is made to track the moving vehicles through the simulation traces which are generated. From this the travel cost of each EV is achieved. The results show that the proposed method is way better than the traditional EV charging strategy.

E. Fadel, proposed a honeybee mating optimization-based routing algorithm with the channel assignment which are cooperative. The model considerably decreases the packet loss probability and link quality between the nodes were preserved in smart grid environment. The parameters such as packet delivery ratio, energy consumption and delay, on the basis of which the evaluation of architecture was done. The developed CRN method balances the load of energy and make the life of smart grid network long. Results showed that the model outperforms the current design solutions in the terms of transmission delay, packet delivery ratio and residual energy in smart grid applications.

Angela Sara Cacciapuoti, studied the problem Tv white spaces spectrum in urban scenarios for smart grid networks. The optical switching procedure was proposed which aimed at maximizing the throughput in the neighbor area network. The system proved to considerably improve the performance of the smart grid in terms of reliability, latency and rate of data. Additionally the optimization of switching procedure was done.

Yijia Cao, proposed a charging method which is intelligent for EV. The main purpose is to decrease the stress of smart grid under heavy demand and to come across the requirements of market. Comparative analysis of charging pattern is done. Simulation results were presented of multiple an single EVs.

Saud Althunibat, investigated the the problem of channel selection of cognitive radio in smart grid environment. It offers high data rate and the reliability based methods shorten the transmission delay. Simulation results showed high performance of the proposed mechanism than the existing methods. This method can be applied to real time environment taking in care the transmission node abilities.

III. CONCLUSION

Smart Grid technologies grasp the potential of able to resolve many of glitches presently in the electric power industry. Though, the deployment at large scale of these novel technologies has been partial due to an incapability to precisely model their effects or to enumerate their possible benefits. In this paper different technologies working in making the smart grid energy efficient is described. The efficiency of moving electrical vehicle is dependent upon the energy utilized by it in an efficient way. Every vehicle in the system need charging model to efficiently communicate and transfer their data to other moving EVs in the smart grid. So in this case, accurate charging model need to be taken taking in all the power conditions, smart grid environment

conditions, location of nearby CV in smart grid to improve the utilization of energy.

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