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WIMAX-WLAN ANALYSIS OF SMART GRID IN NS2 MODEL

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ABSTRACT—Challenges of Vehicle to Grid (V2G) power transmission in Smart Grids include dealing with a large number of Plug-in Electric Vehicles (PEVs), establishment of a robust and reliable communication network for short burst transmissions. Enable V2G power transmission based on WiMAX WLAN hybrid network architecture in Smart Grids. Energy scheduling algorithm is presented for an efficient admission control process and Linear Prediction model is for initiate the aggregation. WIMAX-WLAN was modeled to examine the performance of the energy scheduling algorithm and the communications network for large scale V2G power management.

KEYWORDS— V2G, PEVs, WiMAX, WLAN, Hybrid network

I. INTRODUCTION

Transformation of conventional power grids into Smart Grids promises revolutionary changes through extensive usage of renewable energy resources which will enable „green power‟ generation. Oil price increases and the shift towards green technologies are motivating the transportation industry to introduce electric and hybrid vehicles. The oil price touched a peak value of $147 per barrel in 2008 and according to the Electric Power Research Institute (EPRI) 35% of the total vehicles in the USA will be Plug-in Electric Vehicles (PEV) by 2020. As a demand source, new PEVs or Hybrid PEVs (HPEVs) draw a substantial electrical load from the grid in order to keep them operating. As a supply source, PEVs could act as a mobile power storage device which may store energy from a renewable resource and provide a back up supply in times of need.

PEVs often remain parked for long periods of time, recharging for some of this time and PEVs typically travel over similar routes daily. Vehicle to Grid (V2G) power transmission may reduce the grid‟s load during peak demand or at times when the grid is under stress due to unexpected events. According to PEVs battery storage varies between 1 to 30 kWh and the output varies between 0.2-6 KW if the battery requires 5 hours to charge or discharge. Thus, with V2G there is an opportunity for real-time demand response (DR) programs and ancillary services like peak power and spinning reserves to be implemented. However, to enable these services with a large number of PEVs, additional equipment such as aggregators at different smart grid domains are required, argues that a Mid-Atlantic US (PJM) power grid operator can aggregate up to 1MW of power from a fleet of 100 vehicles with 15KW V2G.

In this paper, a network controlled V2G load management scheme for discharging PEVs is presented which utilizes the bidirectional communication capabilities of the Smart Grid. In order to initiate aggregation from the fleets parked at the charging/discharging stations, a prediction algorithm is developed based on a Linear Prediction (LP) model. Also, a HetNet based Machine-to-Machine (M2M) communication system is introduced to provide V2G aggregated load management for peak shaving. An energy scheduling algorithm is proposed to ensure priority and smart forecasting of large-scale PEV discharging under the proposed scheme. Using an OPNET simulation model, we analyze the performance of the proposed algorithm over a WiMAX-WLAN wide-area Smart Grid communications network.

The rest of the paper is organized as follows. Section II briefly reviews related work and highlights our key contributions. Section III introduces the proposed V2G load management scheme and describes its key features. Section IV presents the communication network model for the proposed V2G scheme. Section V presents the simulation results and analysis. Finally, Section VI concludes the paper and provides guidance for future work.

Figure 1 Illustration of typical smart grid

A smart Grid must be capable of providing power from multiple and widely distributed sources. E.g., wind turbines, solar power panels, photovoltaic panels and even Plug in Hybrid Electric Vehicles. It must be capable of flexibly storing electric power for later use. To improve power reliability a smart grid must make use of new and highly sophisticated adaptive generation and distribution control algorithms.

II. PROPOSED SYSTEM

In our proposed method we consider an efficient optimization technique along with a robust Heterogeneous communication network. Our proposed architecture consists of

1. Parking spaces with charging/discharging stations.
2. PEVs
3. WiMAX Base Station
4. WLAN Access Points
5. Control center

A. *Conceptual Model*

Energy Aggregation is initiated based on a request sent by the control center. The energy is stored in the power banks. The control center determines the time to initiate a request based on peak demand forecasts. The WiMAX network is used to provide link communication to the control centre. The owners of PEVs receive a permission request message to initiate energy discharge.

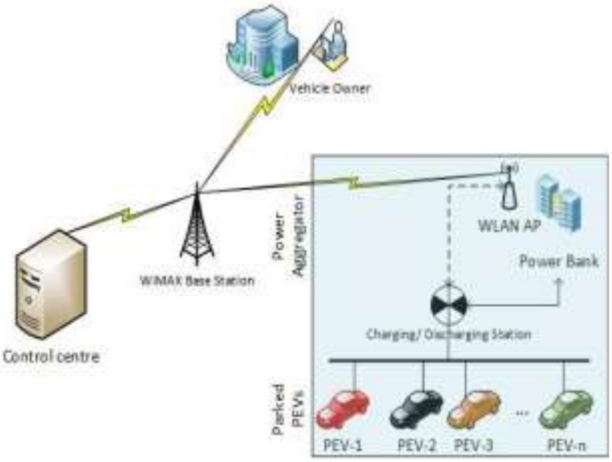

Figure 2 Modes of connectivity within the proposed V2G system

B. *V2G Power Transmission*

Electric-drive vehicles, whether powered by batteries, fuel cells, or gasoline hybrids, have within them the energy source and power electronics capable of producing the 60 Hz AC electricity that powers our homes and offices.

When connections are added to allow this electricity to flow from cars to power lines, we call it "vehicle to grid" power, or V2G.

Vehicle-to-Grid (V2G) technology utilizes the stored energy in the EVs batteries to contribute with electricity back to the electrical power grid, when the grid operators request it.

This way the PEVs can deliver the power back to the power grid during the periods of great demand.

The batteries charging system needs assistance of an intelligent and collaborative system to control both processes.

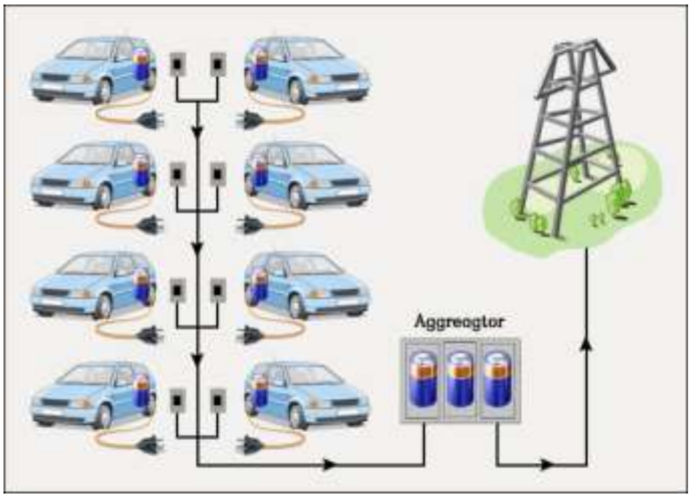

Figure 3 Shows concept of V2G Power Transmission

C. *V2G in WiMAX WLAN*

Electricity flows from generators through the grid to electricity users. Electricity flows back to the grid from the batteries in EV. The control signal from the grid operator (ISO) could be a broadcast radio signal, a cell phone network, or power line carrier. The grid operator sends requests for power to a large number of vehicles. The signal may go directly to each individual vehicle, to a fleet operator, or through a third-party aggregator to dispatch power from individual vehicles.

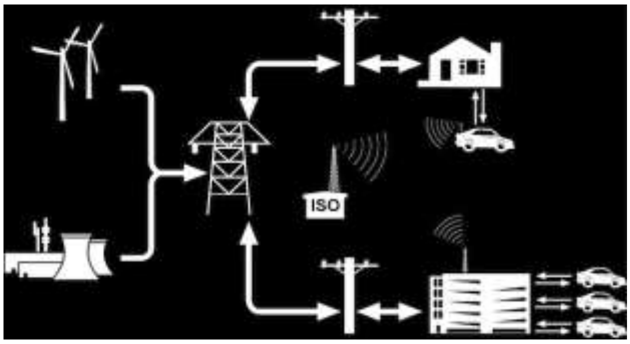

Figure 4 V2G in WiMAX network

D. *WiMAX and WLAN*

WiMAX is Worldwide Interoperability for Microwave Access. It is used for providing broadband data connection to user similar to DSL. It supports various RF bands depends on country allocations. It can cover radius about 50 km. It can support data rate of about 70Mbps theoretically with higher modulation scheme such as QAM.

It can connect two or more than two devices using some wireless distribution method such as spread spectrum or OFDM radio. It provides WLAN users the mobility to move around within small coverage area inside office or building premises.

III. EXPERIMENTAL RESULTS

This approach utilizes a prediction algorithm to estimate the peak demand and then the aggregators coordinate available energy resources (PEVs) via statistical multiplexing to provide differentiated energy supply for handling peak demand.

Also, the controller is required to communicate with a limited number of Access Points (AP) which reduces the overall system communications load and evenly distributes the communications load by randomizing the uplink packet transmissions from the APs.

Hence, in terms of communication overhead, the scheme is highly robust and scalable and can be integrated with other Smart Grid applications.

Figure 5 Network Design

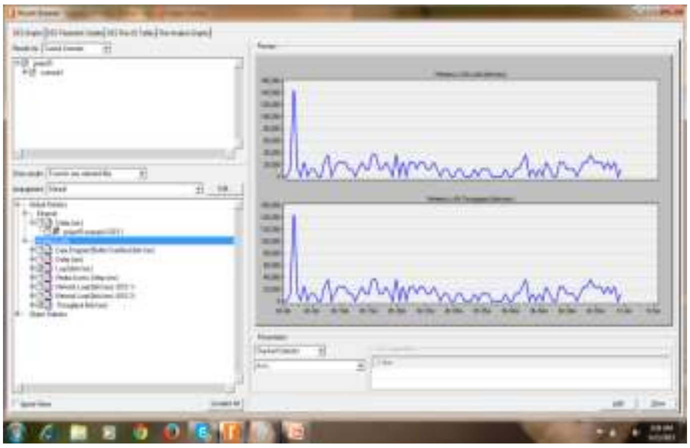

Figure 6 WLAN-Load Vs Throughput

A wireless local area network (WLAN) links two or more devices using some wireless distribution method (typically spread-spectrum or OFDM radio), and usually providing a connection through an access point to the wider Internet. This gives users the mobility to move around within a local coverage area and still be connected to the network. Most modern WLANs are based on IEEE 802.11 standards, marketed under the Wi-Fi brand name.

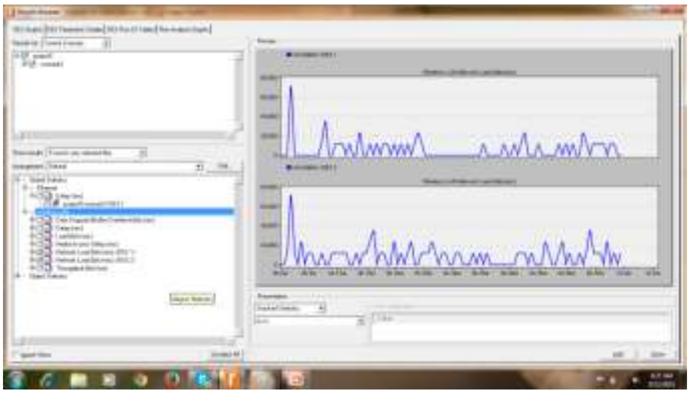

Figure 7 Network Load BSS1 and BSS2

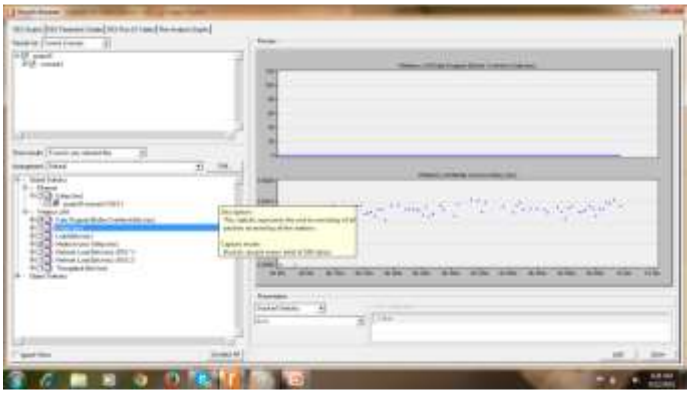

Figure 8 WLAN Data Dropped Vs Media Access Delay

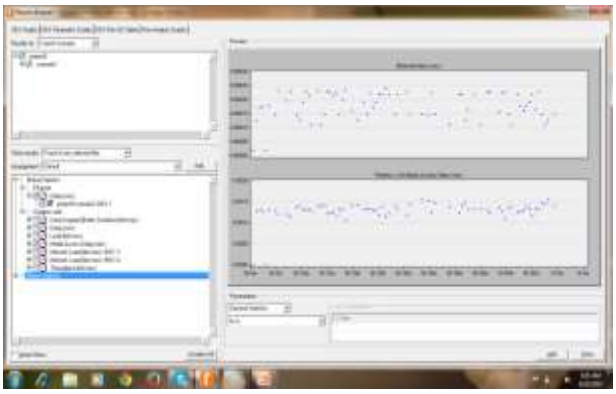

Figure 9 Media Access Delay

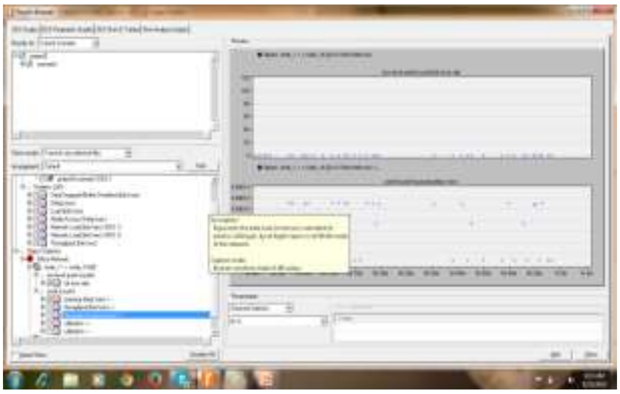

Figure 10 BER and Queuing Delay

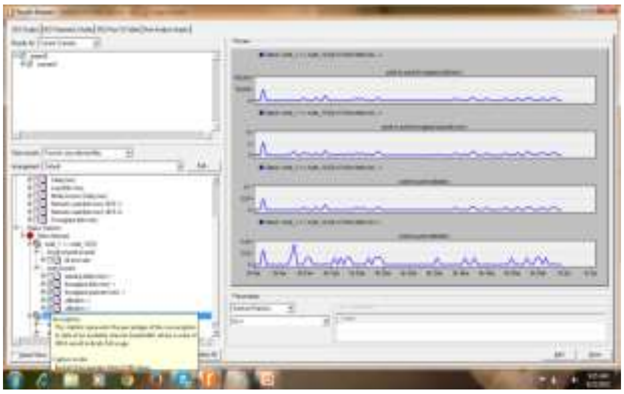

Figure 11 WiMAX Throughput and Utilization

IV. FUTURE WORK

In the future work, the life of battery should be extended to a long extend and fast charging is achieved. The simulation model for the electric vehicle battery and charging station is mainly developed for power grid transient analysis. Further models will be needed for long term simulations where the charging cycle and some other battery parameters should be considerate in the model. The simulation work was developed in Matlab/Simulink; future simulation work will need to migrate to some other advanced power system simulation software packages, with more rich DG simulation models and for large scale power grid simulations.

V. CONCLUSIONS

A wide use of PEVs will bring many benefits, but it may cause several drawbacks too. Choosing appropriate PEV management strategies will be needed in order to minimize PEVs operating costs and their impact on the power system. V2G would appear to be one of the most promising solutions. In particular, V2G is especially profitable in providing ancillary services, such as load leveling, regulation and reserve. Moreover, RESs support can be a viable alternative once the other services are saturated. This analysis of the literature reveals that different ways to perform V2G exist. Hence, the most suitable one should be carefully chosen on the basis of a holistic analysis, which depends on specific goals and local environments and takes into account technical, economic, planning and mobility aspects.

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