Position Statement for 2013 CPS Energy Workshop

Title: Towards Cognitive Radio Communication based Green Electrical Vehicle (EV) Micro-grid

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1. Introduction

Today, Plug-in Electrical vehicles (EV) such as electrical car (BEVs), plug-in hybrids (PHEVs) and solar-assisted vehicle have reshaped the future transportation and power grid infrastructure. Connecting such vehicles to smart grid for smart charging, smart billing, smart grid services, renewable power distribution and scheduling could significantly save the word-wide energy and benefit grid customers. Mass use of EVs requires support from a powerful and robust power grid that can efficiently generate, aggregate, and distribute a large amount of energy in real time with low carbon emission. Such a system calls for a "Green" micro-grid to be established in the either city and large resident community using modern communication technologies for reduce the cost of EV charging infrastructure.

2. Objectives

The research objective is to *exploit novel cognitive radio based wireless communication infrastructure for the design of emerging vehicle micro-grid that integrates sensing and communications for power charging and distribution under "green" (e.g., renewable energy) and mobile environment*. The proposed micro-grid system will deal with the unbalanced and dynamic distribution of car charging events and is highly resilient to huge load fluctuations with energy efficiency.

Some EV charging schemes have been designed to suggest the optimal power load scheduling and dispatch, and EV charging scheduling. However, the efficiency of all these schemes is highly dependent on the day-ahead power markets that forecast electricity price and PEV power demands in the second day. However, the EV power demands and consumption are varied with the time and space, and thus their solutions are sub-optimal and hard to adapt the real word condition. Wireless communication networks can help to address this weakness by providing EVs with real time sensing data and guided EV scheduling. On the other hand, the wide deployments of heterogeneous wireless networks in the city or community have led to scarce spectrum resources and increased communication interferences. The cognitive radio networks with the premium advantages of spectrum selection and reduced interference can provide a reliable and adaptive communication platform for such a EV micro-grid. Therefore, in this project, the PIs proposed to build up cognitive radio based communication infrastructure to connect the EV user demand with the power grid efficiency so that the EV users can be well guided for the power charging under this vehicle micro-grid. As shown in Figure 1, in the project, we plan to deliver GPS-like user interface that guides the user charging on the route in the real time. We will integrate the proposed EV charging algorithm into an existing GPS device and validate our solutions in the long term.

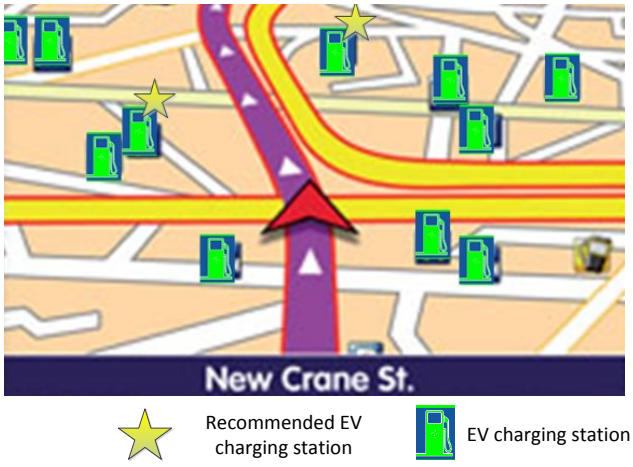

Figure 1: EV charging recommendation

The major challenging questions for establishing this vehicle micro-grid is (1) how to integrate the real-time sensing and communications of EV under mobile wireless

environment (**communication infrastructure**); (2) based on EV charging demand, how to deploy the EV charging stations in a cost-effective manner (micro-grid **infrastructure**); (3) How to utilize aggregated sensing data including smart meters and locations of EV, the environmental information of renewable energy sources to guide the EV charging in real time (**applications**). To address these three major challenges from infrastructure and applications, our proposed project includes five research tasks: (*1) Time-constrained information aggregation under cognitive radio based micro-grid communication infrastructure; (2)reliable solar energy prediction for efficient power distribution; (3) Optimal deployment of monitoring and charging networks for efficient power distribution in green vehicle micro-grid; (4) Distributed algorithms for vehicle power charging and flow optimization;* (5) *Performance modeling and evaluation including establishing testbed*.

3. Summary

The ultimate goal of this research is to *develop cognitive radio technology and EV charging network to support and operate the future green vehicle micro-grid infrastructures*. We will develop advanced EV power charging algorithms and cognitive radio transmission strategies in vehicle micro-grid to meet the needs of utilities, vehicle users, and the renewable power producers. Collected information from smart meters in EV and the grid vehicle participants will be used to develop real time power load forecasting and power charging scheduling that will be interfaced with the power distribution and transmission control centers.