

Abstract

Energy replenishment strategies are the crucial aspect of the widespread adaptation of the various energy constrained devices and vehicles (ECDVs) including unmanned aerial vehicles (UAVs), wireless rechargeable sensor nodes (WRSNs), and electric vehicles (EVs). Effective pricing strategies play a pivotal role in fostering the sustainable implementation of UAV and WRSN based applications including wireless communication, agriculture, environmental monitoring, and smart cities developments. Further, the EVs has received a great attention of researchers due to the development of battery technology and environmental issues. Moreover, the optimized pricing structures can incentivize investment in research and development, leading to technological advancements and cost reduction. Therefore, in this thesis we present a comprehensive pricing based schemes for the promising competitive market applications including UAV to UAV charging, UAV enabled charging of WRSN, and EV charging. A game-theoretic approach is used to obtain the closed form expressions of the equilibrium condition.

In the beginning, the idea of UAV to static UAV (SUAV) wireless charging is envisaged. A competitive market scenario of wireless charging of SUAVs by master UAV (MUAV), capable of wireless energy transfer (ET) is considered, wherein MUAVs are associated with their fixed grounded platforms. A UAV network is considered in which the most economical MUAV is dispatched to the known location of the SUAV and charge without discontinuing the mission of SUAV. Motivated by the fact that an optimized and relevant pricing scheme for futuristic charging service providers (CSPs) will be the critical aspect in the promising competitive market scenarios, a suitable pricing scheme is proposed; and the equilibrium in the market sharing condition using a game-theoretic approach is investigated. The Nash equilibrium (NE) for the total profit for each platform in a non-cooperative competitive environment is derived by

analyzing their corresponding best prices. In this regard, a closed-form expression of the decision boundary for the SUAVs, based on area division, is identified.

Next, the on-demand charging of the WRSNs in a competitive market scenario is proposed. The wireless charging of the independent WRSNs in a network is modeled as a service in a common competitive market, where multiple CSPs indulge in a pricing war to maximize their profits by achieving fair market share based on area division. The grounded CSPs are associated with UAV-enabled chargers (UAVEC), which are dispatched to the concerned WRSNs with known positions and recharged wirelessly in a time-bound manner. A suitable pricing strategy for on-demand charging of the WRSNs in a competitive market scenario is studied, and the existence of NE for prices and profit of CSPs is investigated using a game-theoretic approach. The closed-form expressions of NE conditions and the CSP selection criterion for WRSNs are obtained, and the results are verified through simulations.

On the other hand, the charging infrastructures and pricing are crucial for the widespread adaptation of EVs. Therefore, we present a suitable pricing scheme for charging EVs in a competitive discrete-time dynamic market scenario, wherein multiple electric vehicle charging stations (EVCSs) adapt a comprehensive pricing model to maximize their profit. We study a pricing scheme for EV charging, where we use the updated information, such as EVs traffic distribution, locations of potential EVCSs, expected waiting time at each EVCS, grid energy cost at each EVCS, and the selfish behavior of EVs. The decision criterion for EVs in the considered network is studied for EVCSs. The NE profit of the EVCSs is obtained along with their prices at equilibrium.

Further, we introduce a modified game setup that alleviate the limitations of a conventional Hotelling's game (CHG) application in EV charging to achieve the price equilibrium among multiple non-cooperative players in a discrete dynamic market. In a CHG it is assumed that each player has a positive market share. However, a CHG provides positive utilities to all players at NE only if all the players choose their prices that satisfy the market sharing condition (MSC). The NE price depends on the locations of the players; therefore, the maximum utilities can be achieved only if locations of the players are confined such that the resultant NE price satisfy the MSC.