

## A Double-Auction Mechanism for Mobile Energy Sharing Networks

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### Abstract

The objective of this research article is to address the problem of mobile energy sharing network (MESN). In MESN, electrical power can be transferred directly from one mobile device to another. The concept of energy harvesting is existing, it is a promising technology in current commutation networks. We introduce a double auction mechanism to obtain a method that supports energy trading among mobile users (MUEs). By applying the proposed economic model to MESNs, it will get more benefits and motivation from mutual trade. Also, we introduced a scheme comprised of two algorithms to help the auction system and to perform it with efficiency and stability. The proposed mechanism is based on Preston-McAfee Double Auction Protocol (PMDA). Our experimental results show that the proposed mechanism achieves higher total utility and has good scalability characteristics.

### 1. INTRODUCTION

With the expanding of wireless application, data traffic in wireless network, the power consumption of mobile devices has been increasing because of running application or transmitting data. Many mobile devices run out of power at a crucial moment, with mean lowering network usability and functionality [1]. Meanwhile, mobile device needs to be charged or replaced their battery immediately. In reality, there are many ways for a mobile device to recharge its battery by using electrical source or visit some place supporting energy charging. Energy supply is one of the biggest challenges faced in the wireless communication [2]. A number of efforts have been performed in the literature for solving this problem: increasing battery's lifetime, reduce power consumption [3], [4], [5]. Consequently, mobile energy sharing in network has been introduced for wireless communication network. A network in which the energy can transfer from one user to another depending on the current battery state, capacity of their batteries, the power consumption or requesting.

In the mobile environment where MUE meet each other

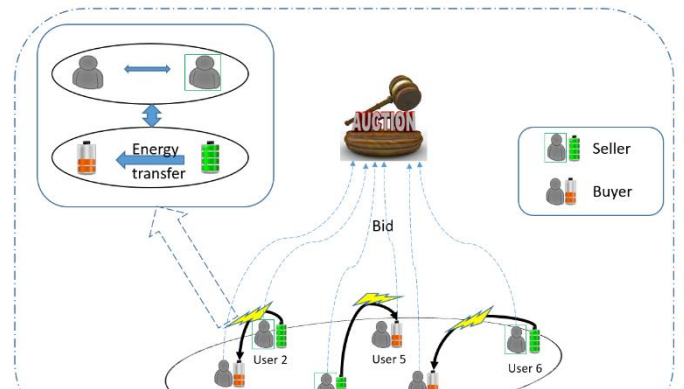


Figure 1: Network model

they can transfer or share i.e., (sell)/receiving or recharge (buy) the energy gaining mutual benefits. Thus, wireless energy transfer become a novel paradigm solution for energy harvesting system. The goal of this paper is to introduce a new game theoretic framework for energy trading in energy sharing network, using auction-based mechanism. When a user who have enough power in battery, he can share (sell) his electrical power via an auctioneer. For the buying side, we can have a user who have less power in battery, and is willing to charge, so he can bid to

the auctioneer. For example, in the figure 1, MUE2 has enough energy to share and energy with MUE1 is less, then, MUE1 can get an amount of power by charging from MUE2.

## 2. NETWORK MODEL

We consider a network consisting of a number of mobile users which can be divided into two disjoint set, the first one is a set consisting of  $m$  MUEs who have energy in the battery (MEB), and are willing to sell their power, and the second set consists of the remaining  $n$  MUEs who are low in energy also referred as low in the battery (LEB), and wants to buy an amount of power for charging. In MNSE, MUE are allowed to sharing energy among each other. Energy can be transferred from one MUE to another MUE depending on the available energy in the battery and the energy consumption or demands. Any LEB want to buy some unit of power. In order to do that, they need to send some information i.e., bid to the auctioneer which includes the number of power units to buy and the offering price. On the other hand, any MUE who wants to sell their energy, have to send the information about their demand price and an amount of power to sell. The auctioneer collects all the bids, the amount of power to buy or to sell. In the Figure 1, we assume MUEs having high powers are sellers, and the remaining MUEs are buyers. After collecting all of the bids, the auctioneer decides the winning buyer and the winning seller. The trading occurs after winning buyer pays to the auctioneer and winning seller receives payment from the auctioneer.

## 3. AUCTION MODEL

We consider a wireless charging system, a set represented by  $\mathcal{S} = \{s_1, s_2, \dots, s_m\}$  of MEBs that are willing to sell their electrical power (seller) and a set of LEBs represented by  $\mathcal{B} = \{b_1, b_2, \dots, b_n\}$  who are willing to recharge/buy some amount of electrical power

(buyer), where  $m$  and  $n$  are the number of sellers/buyers in  $\mathcal{S}$  and  $\mathcal{B}$ , respectively.

To buy/sell electrical energy, the buyers/sellers submit bids/offers to a central controller (auctioneer) which supports communication and pricing determination. We assume that the auctioneer can be an access point (AP), or a Base station (BS). Each seller which can be specified as  $s_j = \{e_j, l_j, a_j\}$  where  $e_j$  is the current battery level for MUE  $s_j$ , can be denoted as  $e_j = \{0, 1, \dots, c_j\}$ ,  $c_j$  is a capacity of battery of MUE  $s_j$ .  $l_j$  is amount of batteries of MUE want to sell,  $\mathbf{a}$  is a vector consisting the amount of battery buyers want to sell,  $a_j$  is a offers price by MUE  $s_j$ . The ask vector of seller denoted as  $\mathbf{a} = \{a_1, a_2, \dots, a_m\}$ . Also, for each buyer  $b_i = \{e_i, k_i, p_i\}$  where  $k_i$  is amount of battery of MUE  $b_i$  wants to charge/buy,  $k$  is a vector represented total amount power units a buyer want to buy, and  $p_i = \{p_i^1, p_i^2, \dots, p_i^m\}$  is the bid vector of MUE  $b_i$ . The bid matrix denoted as  $\mathbf{P} = \{p_i | i = 1..n\}$  and it consists of all bid vector of buyers in LEB set.

The utility of LEB  $i$  denoted as follows:

$$u_i^b = \sum_{j=1}^m x_{ij}(v_i - \rho_i)$$

And the utility of MEB  $j$  denoted as:

$$u_j^s = \sum_{i=1}^n x_{ij}(\varphi_j - v_j)$$

## 4. PROPOSED ALGORITHMS FOR UTILITY MAXIMIZATION

In this section, we introduce the algorithm MURB. For proposed, we also show the results of MURB and individual rationality of algorithm. All results are showing the bid matrix of all buyers, efficiency utility for buyers and sellers. Our proposed algorithm to maximizing utility with respect to buyer based on Preston-McAfee Double Auction Protocol (PMDA).

**Algorithm 1: Maximize Utility Respect To Buyer**

1. For  $b_i \in B$  do
2. Looking for candidate winning buyer and winning seller.
3. If  $u_i^b(s_j) > u_i^b(s_{-j})$  then
 
$$B'_w \leftarrow B'_w \cup \{b_i\}$$

$$S'_w \leftarrow S'_w \cup \{s_j\}$$
4. For  $s_j \in S'_w$  do
5. If  $u_i^b(s_j) > u_{-i}^b(s_j)$  then
6. Decides winning buyer and seller based on their utility with each other.
 
$$B_w \leftarrow B_w \cup \{b_i\}$$

$$S_w \leftarrow S_w \cup \{s_j\}$$

Determine price and payment.

**5. SIMULATION RESULTS**

In this section, we have shown the results of our algorithm and numerical results.

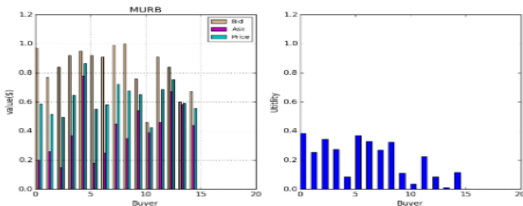


Figure 2: Maximizing utility with respect to buyer

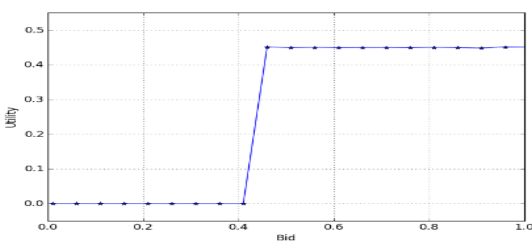


Figure 3: Individual rationality of algorithm

Simulation results show that the proposed mechanism achieve higher total utility and has good scalability characteristics as shown in fig.2 and 3 respectively. In figure 2 shown that, the seller could not improve their utility with different ask, and the figure 3 shown that with the individual rationality are equal likely. Also, our algorithm satisfied the economic properties for any double-auction mechanism is no buyer paid more than their bidding and no seller has

payment less than their asking.

**6. Conclusion**

A double auction mechanism to obtain a method that supports energy trading among mobile users (MUEs) was proposed. Furthermore, we introduced a scheme enhances the efficiency and stability of the system. Simulation results have been presented to demonstrate our preposition.

**7. Acknowledgement**

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