Six-Tuple Bid Model for Time-Shifting Devices in Agent based Supply-Demand Matching Mechanism

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Abstract

Electricity sectors is moving to a new era of so called Smart Grids with increasing important role of ICT. To cope with the anticipated challenges, concept of Multi-Agent System (MAS) is introduced in distribution network as a de-centralized demand balancing paradigm to effectively manage the dispatchable loads, distributed generations and storage. In this paper, a new bid model is presented for MAS based active distribution networks (ADNs). The complete paper will also develop the algorithm for concentrated bid using dynamic programming and present simulation results to discuss the applicability and efficacy of the algorithm.

Keywords
Active Distribution Network, Bid Model, Multi-Agent System, Time-shifting Devices

1 Introduction

The current advancements in control theories and intelligent communication technologies has increased the penetration of Distributed Generation (DG), Storage Systems, Electric Vehicles (EVs) and Dispatchable Loads (DLs) which are transforming the conventional passive network into Active Distribution Network (ADN) [1, 2]. Over this emerging concept, many researchers have presented a variety of solutions for ADNs. Among these, one of the promising solutions is the concept of Multi-Agent System (MAS) which has presented the decentralised bottom-up approach with an aim to provide flexibility and scalability [3].

Multi-agent system design paradigm with a coordination mechanism for matching supply and demand in distribution network is well demonstrated in Power Matcher Technology [4]. This technology has an aim to develop algorithms and strategies for Market Model and Resource Allocation under normal operating conditions. In PowerMatcher (PM) Technology, several Distributed Energy Resources (DERs) including including heat pumps, microcombined heat and power plants, photovoltaic systems and smart washing machines are integrated and represented by the agents. In PM, all agents of DERs are organised in a tree structure as shown in Fig. 1.

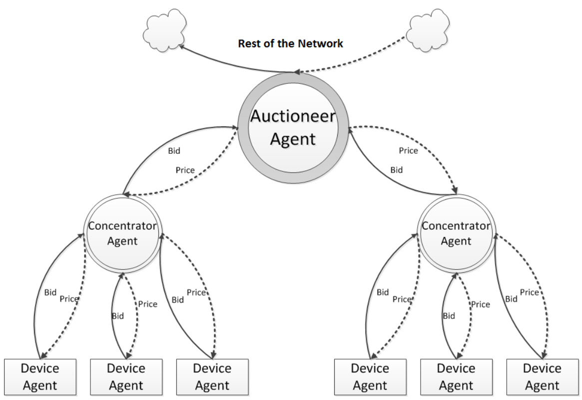

Figure 1: Multi-Agent based Power Matcher Architecture

2 Problem Formulation

In this paper, the problem is formulated for MAS based Power Matcher Architecture in which a new bid model is proposed for all device agents , with a goal to maximize the profit by considering customer constraints in term of it's participating agents/devices. To comply with this objective, the device agent a_i is modelled by a 6-tuple represented as

$$a_i \rightarrow [d_i, b_i] \ \rightarrow [(s_i; f_i; t_i^{on}; t_i; r_i), b_i] \quad (1)$$

where d_i shows the state of the i^{th} device/agent, $[s_i; f_i]$ denotes the interval during which the device may be switched on, s_i is the start point or lower limit and f_i is finish point or upper limit in time; t_i^{on} denotes the total duration for which the load should remain "on", t_i denotes the minimum duration for which the load must be on continuously during interval $[s_i; f_i]$, r_i denotes the power rating of the load and b_i denotes the respective price bid in €/kWh. For example $d = [2; 10; 3; 1; 1.5; 1.5]$, means that the load j, which has a rating of 1.5kW with a bid price of 1.5€/kWh can be turned on anywhere between the 2^{nd} and the 10^{th} interval. Once it is turned on it can be switched off only after 1 interval and will need total 3 intervals to complete its load cycle, as shown in Fig. 2.

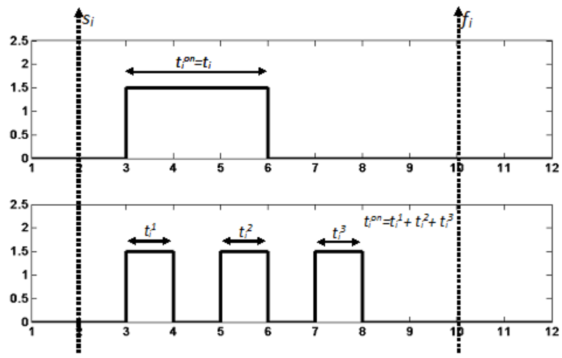

Figure 2: Bid Model

Moreover, the paper also presents the strategy for concentrated bid generation by using the dynamic programming [5]. Therein the optimization variables are the market price , send by the auctioneer agent, and the state d_i of the device. Thus, The concentrated bid is obtained by solving the optimization problem i.e.

$$\min \sum_{i=1}^{I} (b_i \times u_i(k)) \quad \forall\ i = 1, 2, \ldots I$$

Where, $u_i(k)$ denotes the status of the i^{th} load during the k^{th} interval. Finally, the algorithm will have an aim to optimally schedule the loads which benefit in saving money for the customers as well as keeping the demand at a limit which benefits the supplier or the utility. This can make the demand response a win-win scenario.

3 Conclusion

The complete paper will develop the algorithm for concentrated bid using dynamic programming and present simulation results by using few consuming and producing agents to discuss the applicability and efficacy of the algorithm. The concentrated bid will be calculated for two cases i.e. fixed and dynamic bid b_i forall a_i agents.

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