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Master Thesis

Using Machine Learning and Data Analytics Techniques to Design a Competitive Broker for an Electricity Market Simulation Environment

Wicked problems like sustainable energy and financial market stability are societal challenges that arise from complex sociotechnical systems in which numerous social, economic, political, and technical factors interact. Understanding and mitigating these problems requires research methods that scale beyond the traditional areas of inquiry of information systems (IS) individuals, organizations, and markets and that deliver solutions in addition to insights. In [1], the authors address these challenges through competitive benchmarking (CB), a novel research method that helps interdisciplinary research communities tackle complex challenges of societal scale by using different types of data from a variety of sources such as usage data from customers, production patterns from producers, public policy and regulatory constraints, etc. for a given instantiation.

Against this backdrop, the Power Trading Agent Competition (*Power TAC*, http://powertac.org/) is a competitive simulation platform for the power sector which was built on the basis of competitive benchmarking principles. Power TAC allows to test and assess business models and strategies in a risk-free manner. Furthermore, based on experiments and sensitivity analyses, one may derive policy implications, for example with respect to market design. Within Power TAC, dozen research groups from around the world jointly devise, benchmark, and improve IS-based solutions. Power TAC models a “liberalized” retail electrical energy market, where competing business entities or “brokers” offer energy services to customers through tariff contracts, and must then serve those customers by trading in a wholesale market. The retail market is a tariff market, in which customers are able to choose among tariff contract offerings from the competing brokers. Customers are models of household, business, and institutional users of electric power, as well as small-scale producers of power that own solar arrays or small wind turbines [2] [3].

Once a year a Power TAC competition is launched in which loose groups and institutions from all over the world are granted the option to implement a broker and test their strategies within a competitive simulation framework. More precisely, brokers are challenged to maximize their profits by buying and selling energy in the wholesale and retail markets, subject to fixed costs and constraints; the winner of an individual “game” is the broker with the highest bank balance at the end of a simulation run. Costs include fees for publication and withdrawal of tariffs, and distribution fees for transporting energy to their contracted customers. Costs

are also incurred whenever there is an imbalance between a broker's total contracted energy supply and demand within a given time slot.

The crux of this thesis is to extend and improve an already existing Power TAC broker (*ewiBroker*) to successfully participate in the next Power TAC competitions and potentially even win them. The broker extensions shall be based on suitable machine learning and data analytics techniques. A successful broker design is expected to comprise suitable strategies for all of the three relevant markets (customer market, wholesale market, and balancing market). As an additional cornerstone of the broker design we target implementing self-assessment routines that allow for modifying the broker strategies during individual competitions based on the respective relative performance. This approach is motivated through the idea of implementing a strategy which reacts to the behavior of the opponents. The thesis shall also include a detailed analysis of the broker performance within several test simulations. Besides the absolute performance, special focus is to be placed on understanding what is driving the overall broker performance.

The broker implementation will be based on the JAVA programming language.

Literature References:

[1] Ketter, W., Peters, M., Collins, J., Gupta, A.: Competitive benchmarking: An IS research approach to address wicked problems with big data and analytics. Management Information Systems Quarterly 40(4), 1057–1080 (2016a)

[2] Ketter, W., Collins, J., Reddy, P.: Power TAC: A competitive economic simulation of the smart grid. Energy Economics 39, 262–270 (2013)

[3] Ketter, W., Peters, M., Collins, J., Gupta, A.: A multiagent competitive gaming platform to address societal challenges. Management Information Systems Quarterly 40(2), 447–460 (2016b)

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