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EXPLOITING RENEWABLES BY REQUEST-BASED BALANCING OF ENERGY DEMAND AND SUPPLY

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OVERVIEW

The energy sector is in transition. First, the deregulation forces companies to restructure their value chain in order to increase their market efficiency. Second, in order to reduce carbon emissions, the use of renewable energy sources is enforced by national and international regulations. Third, smart metering is being widely adopted. The main goal of the MIRACLE project is to develop an ICT system that will enable the integration of a higher rate of distributed and renewable energy sources by leveraging flexibilities in energy demand and supply. The system will provide the means to issue micro-requests indicating these power profile flexibilities (e.g. shifting in time or the energy amount) and to process the micro-request data in a hierarchical fashion. Consumers and producers such as electric heat pumps, charging of electric vehicles, washing machines, dishwashers, photovoltaics, urban wind and micro combined heat and power are taken into account. The developed system enables customers and energy companies to balance energy demand and supply in near real-time and thus, allows the integration of more renewable energy sources whose availability cannot be influenced.

In general, the concept of balancing energy demand and supply already exists. For example, the Danish EDISON project [3] aims to use batteries of electric vehicles as additional accumulators in order to smooth energy demand and supply peaks. As another example, the ADDRESS project [4] uses a real-time demand approach, where energy supply from domestic and small commercial customers are requested by markets and/or other power system participants.

In contrast to these existing projects, in MIRACLE, a micro-request approach is used, where consumers and producers directly specify their demand and supply power profile flexibility in a fine-grained manner (household and SME level). The developed ICT system will be able to support dynamic, near real-time scheduling of micro-requests e.g. when the wind is weaker or stronger than expected. To enable this, our ICT system will be hierarchically distributed. It will aggregate single requests and use feedback-driven forecast models.

METHODS

Figure 1 illustrates a simple example system with two levels, the core functionalities of each level, and the information stored and exchanged. Local energy data management is at the lowest level of the hierarchy, and it uses functionality either provided by a smart meter or a separate energy management device. From the perspective of metering and data management, we distinguish between demand and supply. The system stores historic data and uses it to forecast demand and supply for the near future (i.e. day ahead and intra-day). Local energy data management stores the profiles of the appliances and collects energy requests issued for their use. Consumers and producers issue requests either one day ahead or intra-day. A request is related to a specific appliance (e.g. a dishwasher) or an aggregate and it includes certain flexibilities (e.g., timeshifts). The broker further, aggregates the requests, schedules them depending on its business strategy, and negotiates the use and timing of micro-requests with the producers/consumers. By using shiftable requests, brokers are enabled use more renewable energy because rescheduling can be performed in near real-time in reaction to changed availability of renewable energies.

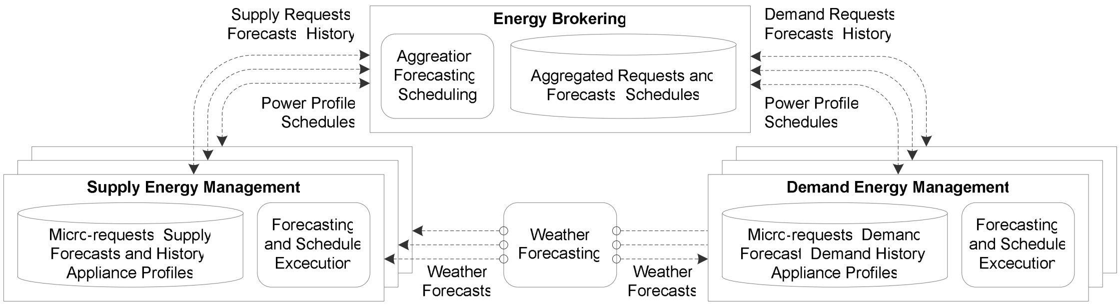

Fig. 1. MIRACLE Architecture for Balancing Energy Demand and Supply

The system relies on three main technical aspects. First, due to the vast amount of requests, data pre-**aggregation** [1] is a key enabling technology. Dimension hierarchies such as time, region, and customer profiles are used for aggregation, where the concrete aggregation scheme depends on the system users and their objectives. The major challenges are (1) to minimize the amount of exchanged data, and (2) to enable efficient processing of seamlessly integrated history and forecast data. Second, reliable model-based **forecasting** of energy demand and supply [2] is needed in order to allow for balancing demand and supply with awareness of trend and multi-seasonal variations (daily, weekly, and yearly). We use individual forecast models on each aggregation level. In detail, we follow the classical approach of model identification, model estimation, and forecasting with exogenous input of e.g. weather data. The major challenges are (1) the distributed forecasting, and (2) the incremental maintenance of forecast models. Third, **scheduling** is a vital part of request-based balancing of energy demand and supply. The time-shifts of requests enable us to balance demand and supply with regard to the computed forecasts. We model this scheduling problem as a constrained optimization problem and we will develop a robust and adaptable scheduling method. Beside the large search space, the major challenges are (1) the tight and adaptable integration of scheduling with the negotiation of actors, and (2) the time-based incremental maintenance of schedules in case of changing forecasts.

CONCLUSIONS

In this paper, we have described the objectives of the MIRACLE project, the conceptual system architecture, and the three major technical issues of (1) efficient processing by aggregation, (2) accurate forecasting of energy demand and supply, and (3) scheduling shiftable requests. For a holistic view on balancing energy demand and supply, additional aspects such as privacy, organizational issues, dynamic pricing, and robustness must be addressed in the future as well.

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