SDU ENERGY INFORMATICS

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Software Technology for Resilient Energy Systems

Background

According to Dansk Energi, the demands of consumers changes because grid entities such as electric vehicles, heat pumps, solar panels etc. gets more common. Some of these entities produce power which causes congestion on the grid. This also means that power production transitions from being centralized to decentralized. The power grid capacity is therefore gradually expanded, but it is estimated that a full investment cycle to handle consumer needs is finished in 2060 [1]. Consuming and Producing grid entities should therefore be able to support demand and response to increase utilization of the existing grid infrastructure while maintaining consumers expectations of high availability. It is the plan that all (3.2 million) Danish end-customers should have smart meters installed ultimo 2020 [2]. Simultaneously, political incentives accelerate this process. Recently, the Danish government agreed upon a national climate plan with binding targets that serves the purpose of accommodating the Paris Agreement by 2050.

The literature refers to the problem of intelligently balancing power demands and supply as Demand Side Management (DSM) [3]. DSM involves complex relationships between a range of actors e.g. consumers, aggregators etc. [4]. The implementation of DSM is enabled with the integration of technologies such as smart meters, virtual power plants, profiling, algorithms etc. which supports trading and thus avoiding congestion on the grid. Previous research has explored the potential of such technologies in the context of Data Centers, Greenhouses and retail buildings and in a wide range of other areas [5], [6], [7].

Evolutionary algorithms (EA) is one of the suggested optimization techniques used to search for solutions with the goal of satisfying various objectives in DSM. The state of the art includes variants of EA, namely NSGA-II, SPEA2, SMS-EMOA, MOPSO and MOEA/D. Each of the variants have their strength and weaknesses and selecting one depends on the application. Multiobjective evolutionary algorithms (MOEA) have previously been applied in Danish greenhouses to solve the problem of multiple conflicting objectives. This led to the development of a component-based Multiobjective Optimization framework written in Java [8]. This framework offers extensibility and reuse thus allowing developers to define objectives suitable for their application needs.

Problem Statement

Current research has focused on experimenting and evaluating specific technologies which aims at solving the problem of DSM at the edge-level. However there has been a less focus on qualities for preparing the technology at the cloud-level such as availability, scalability and performance. These qualities are equally important to functionality, especially if such systems should be resilient and act autonomously in the future.

Expected Results

The study is expected to research software qualities of cloud-based software systems in the smart grid domain with focus on multiobjective optimization frameworks. Furthermore, concrete cloud-based software qualities will be integrated into a prototype and ideally into a real-world application. Tools for monitoring are an integral part, which can verify that the software qualities of interest are operating as expected.

Project Period

1 September 2020 to 31 August 2024

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