ApoDOSIS: ADvanced Orchestrator for Smart-buildIngS

Kostas Siozios
Department of Physics
Aristotle University of Thessaloniki
Thessaloniki, Greece
ksiop@auth.gr

Stylianos Siskos
Department of Physics
Aristotle University of Thessaloniki
Thessaloniki, Greece
siskos@physics.auth.gr

***Abstract*—This work presents a distributed system for supporting advanced orchestrator of a smart grid environment. By efficiently control energy production from renewable sources and the energy loads, it is feasible to minimize the energy cost. In contrast to similar approaches, the proposed decision-making is performed in a distributed manner, while it also exhibits limited computational complexity.**

I. Summary

The Zero Energy Building (ZEB) concept is no longer perceived as a concept of a remote future, but as a realistic solution for the mitigation of CO_2 emissions and the reduction of energy use in the building sector. The ApoDOSIS ecosystem proposes a novel framework (see Figure 1) to support the efficient, yet flexible, design and physical implementation of multi-objective decision-making mechanisms for supporting the orchestration of these systems. The introduced solution is applicable to a smart-grid environment to far exceed today's levels of autonomy, functionality and usability. The employed computational intelligence algorithm supports dynamic, self-organized and adaptive re-configuration of the ecosystem of distributed components without prior knowledge and/or constant definition of cost function during execution phase. The "self" prefix feature indicates that the systems autonomously decide how to adapt so that it can accommodate changes in their contexts and environments. This property is crucial for enabling inter-operable, re-configurable and dependable CPS ecosystems, as well as for avoiding the fragmentation of existing vertically-oriented closed systems. Also, the orchestrator enables easy customization and coordination phases almost without the interaction of end-users.

A key challenge for this solution affects their inherent heterogeneity, which in turn further complicates the orchestration problem under multiple operating scenarios that need to be analyzed. Additionally, since the ApoDOSIS orchestrator is executed onto low-cost embedded (reconfigurable) platform, the corresponding algorithms exhibit low computational and storage complexities that respect real- or run-time constraints. The proposed framework assists both operators in taking better decision for minimizing the balance between energy generation and consumption, as well as home owners in taking and implementing better decisions for reducing their energy bills. The wide adoption of the proposed orchestrator framework

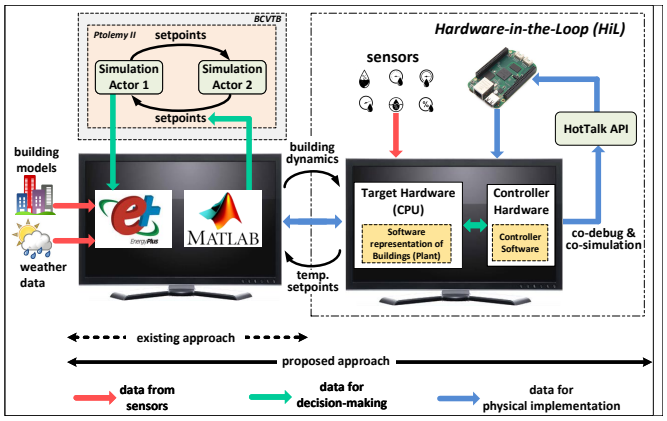

Fig. 1. The proposed rapid prototyping framework.

especially for the residential buildings is expected to be viable due to the low-cost of the employed embedded platform. This solution is evaluated with a smart-grid case study consisted of efficient control of energy production (distributed renewable sources), energy storage at Energy Storage Systems and a Demand Side Management (DSM) system for building's HVAC (Heating, Ventilation, and Air-Conditioning) operation.

The ApoDOSIS orchestrator maximizes energy savings and reduce energy bill by enabling CPS resources (e.g. HVACs, Distributed Energy Resources, DSM, appliances, etc.) to autonomously decide at run-time in coordination, of course, with the other system's components and make sure that users are "satisfied" (what are their best actions for optimally reducing generation/consumption balance and energy bills). Furthermore, enable ecosystem's components to autonomously decide their best actions reduces to the minimum the need for the tedious manual-based system operation that prevents the penetration into the energy market of Energy Service Companies, as well as providers of Energy Management Systems and Building Management Systems.

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