Web of Simulation ontology (WoSO): Integration of Building Performance Simulations in IoT Systems*

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The buildings operation sector is the most energy-consuming sector, amounting to 42% of final energy consumption in France in 2021 [1]. Therefore, acting on the management of energy consumption is key to saving energy in the buildings operation sector. In this context, the use of Internet of Things (IoT) systems in building management can enable significant improvement in energy efficiency strategies. However, Physical phenomena occurring in a complex and heterogeneous connected Cyber-Physical System (CPS), e.g. smart building, are poorly taken into account in current IoT applications. These physical phenomena are often represented by Building Performance Simulations (BPS) which uses mathematical models to simulate the dynamics of the CPS based on observations of connected devices [2]. The synergy between BPSs and IoT systems holds great potential for optimizing energy management in buildings, paving the way for a significant reduction in energy consumption. For this vision to come true, BPSs and IoT systems need to interoperate as part of a smart building management system. Integrating BPSs to IoT systems reinforces a well identified issue facing the IoT field: heterogeneity [2, 3]. To overcome this challenge, our first objective is to make BPSs and IoT systems interoperate as part of a smart building management system. This requires effective data exchange between these heterogeneous systems. Reaching a consensus on shared data model: the Web of Simulations Ontology (WoSO) [4] enables to ensure semantic interoperability between the BPSs and IoT systems. WoSO is a core vocabulary providing a high-level description of BPS relying on the SAREF ontology standard for IoT aspects and the Functional Mock-up Interface Specification to identify and describe information related to the core functionality of a simulation. Our second objective consists in integrating the simulation into constrained IoT devices with the goal of executing them at the edge. This would enable to use the existing resources, minimize time responses, and maintain basic system functionalities during communication disruptions [5]. However, simulations typically require significant resources such as memory, processing capacity, and energy. Therefore, the key concern is to optimize the simulation to be resource efficient and tailored to the architecture of the constrained IoT device. The distributed architecture of the IoT systems inherently involves

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distributed simulation and because of their interdependent nature, co-simulation approach is needed [6, 7, 8]. Co-simulating distributed simulations in IoT system constitutes our third research objective. We plan to experiment our research proposals with two smart buildings: the Espace Fauriel building of the Mines Saint-Étienne Engineering School, and the K15 Smart Building of EDF R&D.

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