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Big Building Data - a Big Data Platform for Smart Buildings

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Abstract

Future buildings will more and more rely on advanced Building Management Systems (BMS) connected to a variety of sensors, actuators and dedicated networks. Their objectives are to observe the state of rooms and apply automated rules to preserve or increase comfort while economizing energy. In this work, we advocate for the inclusion of a dedicated system for sensors data storage and processing, based on Big Data technologies. This choice enables new potentials in terms of data analytics and applications development, the most obvious one being the ability to scale up seamlessly from one smart building to several, in the direction of smart areas and smart cities. We report in this paper on our system architecture and on several challenges we met in its elaboration, attempting to meet requirements of scalability, data processing, flexibility, interoperability and privacy. We also describe current and future end-user services that our platform will support, including historical data retrieval, visualisation, processing and alarms. The platform, called BBData - *Big Building Data*, is currently in production at the Smart Living Lab of Fribourg and is offered to several research teams to ease their work, to foster the sharing of historical data and to avoid that each project develops its own data gathering and processing pipeline.

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1. Introduction

Concerns about climate change have triggered the need for more sustainable and dynamic energy management systems. This is especially true for the building sector, which accounts for about 20% of the energy consumed worldwide [1].

The standardisation of building sensors, for example through IoT technologies, and their coupling to smarter control systems are forming the basis of Smart Buildings, providing new ways for the owners, operators and facility managers to improve both the reliability and performances of building assets. Research wise, smart control systems are intensively investigated with the objectives to save energy and at the same time increase the comfort level. Examples of smart controls are promising, reporting savings from 10% for simple controls up to 60% for the most advanced

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systems. Smart controls are addressing the different sources of consumptions in buildings such as heating, cooling, ventilation, electric lighting and solar shadings [2], lightning [3], electric appliance [4], etc. We observe that such technologies will rely more and more on the gathering of large amounts of data from multiple sensors, actuators and dedicated networks.

The handling of Smart Building data is challenging in many ways. First, the building automation domain has a long history with interoperability problems due to the diversity of systems and technologies [5], leading to interoperability and integration concerns [6]. Second, the density of sensors and actuators as well as the sensing frequency tend to increase for a finer observation and control of the equipments, leading to large quantities of data to process. As an example, in Project Dasher, the database reached its limits after only three months and the collection of 2 billion rows of data [7]. Third, advanced control, monitoring and post occupancy evaluation are relying on more and more complex models using both real-time and historical data, as well as aggregations and correlations in the range of several years. While real-time and time-aggregation processing have received a renewed attention and many frameworks try to address those needs, none of them are currently fully mature [8]. Finally, while the coupling between the IoT and the Big Data is strong, there are few comprehensive approaches to support the collection of data from building sensors to their exploitation. Current research efforts are mainly focusing on the collection of data from the data producer tiers, the reception tiers or the exploitation one [9].

In the BBData project, we attempt to answer those challenges by providing a full-featured data processing platform for Big Building Data. BBData is an ingestion, processing and sharing system able to scale up to the Big Data expectations of Smart Building environments. The project is an applied research contribution of HEIA-FR in the context of the Smart Living Lab in Fribourg. Still in the earlier stages of development, it has been running continuously for several months to gather data from more than two thousands sensors located at the Halle Bleue of the BlueFactory site.

Section 2 presents a general overview of the BBData platform. Subection 2.1 shows how Big Data technologies changed the landscape of Smart Building solutions. Subsection 2.2 presents the architecture of BBData, as well as the technologies that support it. In section 3, we review some of the challenges of big data and how we met them in our solution. In section 4, we present some key features of BBData and how Building professionals could benefit from it.

2. System description

2.1. From BMS to Web of Buildings

In this work, we rely on the inclusion of a dedicated system for the storage and processing of sensors data equipping smart buildings. More specifically, the architecture of this system is remote, de-coupled and based on Big Data technologies. This choice enables new potentials in terms of data analytics and applications development, the most obvious one being the ability to scale up seamlessly from one smart building to several, in the direction of smart areas and smart cities. More than a simple evolution of Building Management Systems (BMS), such open Big Data architectures are probably an important paradigm shift from BMS to what is called *Web of Buildings* [10].

As illustrated on the left part of Figure 1, traditional Building Management Systems (BMS) are standalone softwares running on a server located in the premises of a building. Standard BMS includes three levels of functions: (1) the field layer is made of sensors and actuators connecting to the physical word; (2) the automation layer applies strategies derived from a set of rules and parameters; (3) the management layer configures and manages the other layers. BMS usually offer limited capacities in terms of sensor data storage and act as isolated systems often unreachable from the outside.

The right part of Figure 1 illustrates our BBDATA architecture with the inclusion of remote solutions for storage and data processing. More than the ability of scaling up at the level of a city, this approach brings new opportunities in terms of BMS evolution through the de-coupling of sensors, data storage and applications levels. This opening is supported by the emergence of the open and standardised principles of the Internet of Things and Web of Things [11][12]. It allows for seamless integration of new data sources, such as weather forecasts available in web services or mobile sensors. It also allows for shorter application development cycles, enabling for example mashup approaches as in modern web application development. Finally, the availability of long term historical data allows to use advanced mathematical models and machine learning technique [13].