A Digital Buildings Ontology for Google's Real Estate

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Modern workplace physical environments have become an intersection of various systems mainly aiming to increase occupants comfort, safety, and productivity while reducing operational costs. In order to achieve such requirements, several systems installed in the workplace must be working optimally and in concert with each other. A typical workplace will have separate systems for HVAC, physical security, lighting, and fire control, and many others [8]. For large portfolios, it is usually necessary to have multiple management servers for each system. Each system may connect to hundreds of unique equipment types and variations which are often configured differently across installations. The lack of standardization even across similar equipment within the same system makes it very difficult to integrate and interpret data in order to understand the systems' behavior and provide value-added services for occupants and facility managers.

The adoption of the Internet of Things promoted the connectivity of buildings' sensors, devices and systems to the cloud. Such cloud connectivity is sustained by the ambition of promoting applications which will make use of the collected data. The aim is to rely on the gathered information to drive new business opportunities ranging from monitoring and visualization [8], [9], to energy peak shaving [5], and anomaly detection [12].

Connected things are of heterogeneous types and range from low-end devices such as sensors and actuators to more capable items such as systems which concentrate many devices. In such systems, contextual information of the connected sensors and gateways is organized and expressed more often in a convention or a notation such as the single-line diagram. In a given facility, different systems are usually deployed, such as a Building Management System (BMS) which monitors temperature, humidity and CO2 levels to regulate cooling and heating along with the indoor air quality. A Power Monitoring System is deployed in order to monitor power quality and power consumption of electrical loads often classified by usage such as lighting, heating, cooling and plug loads. Other systems are also deployed to collect presence data or to operate on lighting systems.

These BMS systems supervise and control underlying controllers and devices, which support low level protocols such as BACnet [2], Modbus [10], and others. However, the commissioning process is very fragmented with its diverse tools and naming conventions, and it varies by buildings, vendors, and geography. Such diversity prevents interoperability between buildings making any application consuming the collected data from these systems non scalable or limited to a set of very specific naming convention.

Several initiatives and efforts have been proposed to address the problem. For example, the Building Information Model (BIM) [6] was introduced to become a single point of truth during the design of a building all the way to its commissioning. This process might be applicable to new buildings design but not an easy and cost-effective solution to an already commissioned and operating building. Other schemata such as the Industry Foundation Classes (IFC) [3] and Green Building XML (gbXML) [11] focus on the design and construction and not much on the buildings operations.

More recently, several tag-based conventions and ontologies such as Project Haystack [4] and Brick [1] have emerged to better capture and represent the various components of the HVAC and BMS systems. However, such conventions and ontologies are still very high level and very broad to be applied efficiently on various buildings.

In this work, we overview our Digital Buildings ontology [7] which builds on Haystack and Brick in order to semantically represent many of Google's buildings in the California Bay Area region. The ontology proposed in this work is designed with the help of a subject matter expert in HVAC mechanical systems.

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