TIGHT INTEGRATION OF EXISTING BUILDING AUTOMATION CONTROL SYSTEMS FOR IMPROVED ENERGY MANAGEMENT AND RESOURCE UTILISATION

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Summary

This paper presents interim results of the currently ongoing *Building as a Service* (BaaS) EU project. The BaaS project aims at optimising energy performance of non-residential buildings, e.g. schools, universities, hotels, shopping centres, or sports facilities.

An ICT platform is being developed that integrates IT systems that already exist in infrastructure assets with new IT components delivering novel functionalities extending the performance assessment of buildings. The former include building management systems (BMSs), access control systems, or systems providing weather data. The latter are mostly concerned with the assessment, prediction, and optimisation (APO) of energy usage and modelling. The IT infrastructure systems and APO services are linked by an integration middleware. The main features of this middleware are standardised interfaces via which all communication between the components of the system is routed. Functioning and characteristics of the middleware and its interfaces will be explained in the present paper.

Keywords: building energy management, energy conservation, building control, load balancing, building management system

1 Introduction

Buildings account for 40 % of the global energy consumption. Novel technologies are thus needed to reduce their CO_2 footprint. Large assets are already today equipped with BMSs or HVAC systems. However, most of these systems are entirely isolated, i.e. not integrated with all information available in buildings today. By integrating them into a smart, holistic platform, unprecedented synergies between existing IT systems in buildings and energy APO strategies emerge. To achieve maximum benefit from such a platform, as many data sources as possible, both internal and external to the building, should be integrated.

2 Overview of Existing Building Management Interface Initiatives

Interoperability in building management systems is an ongoing challenge. Over the past years, middleware and interface initiatives have been actively researching this topic.

In [1], as the result of the FP6 European Project (EuP) HYDRA [2], the LinkSmart Middleware is presented as a generic middleware to facilitate the communication of heterogeneous BMSs and devices networks in buildings. In [3], as interim result of the FP7 EuP CAMPUS21 [4], the ECOService Platform is introduced as a modular and extensible software platform designed to allow the integration of existing ICT systems for performance evaluation, benchmarking, and load balancing based control. In [5, 6], as result of the FP7 EuP intUBE [7], an open source platform for the semantic integration of energy information in buildings is presented, highlighting the benefits of creating common sets of vocabularies along the building lifecycle. In [8] an open-source, vendor- and technology-independent toolkit for building data collection and pre-processing is presented.

However, the aforementioned achievements should be joined together to implement the full interoperability concept in the building lifecycle. This paper shows a preliminary architecture approach aiming at this goal.

3 The BaaS System

3.1 Platform Design Paradigms

As shown in Fig. 1, the BaaS system is composed of three main elements: The *Data Layer (DL)*, the *Communication Logic (CL)*, and the *APO Service Layer (APO-SL)*. The *DL* comprises all data sources and storage systems, namely the BMS and the building information model (BIM) of the physical assets, additional data sources (e.g. weather forecast, access control systems), and the data warehouse in which all these data are stored. In contrast, the *APO-SL* hosts the services which analyse and process the data and derive control strategies and commands thereof. The *CL* is implemented as a middleware layer which links the *DL* and *APO-SL*. The *CL* itself consists of two main components, namely the *Domain Controller (DC)* and the *Data Acquisition & Control Manager (DACM)*. The reason for this is that splitting the *CL* into two components allows much greater flexibility in the deployment of the BaaS system compared to its precursor project CAMPUS21 [4]. The *DC* always runs on the site of the assets to be managed whereas the *DACM* is typically hosted in a central, controlled environment (e.g. a data centre), irrespective of the physical location of the asset. This split setup adds to the reliability of the overall system: If the DACM gets unconnected, the DC can still perform local control in a fall-back mode and also buffer BMS data whereas in case of a failure of the DC the DACM can still serve the APO services with historic data from the data warehouse or provide weather forecast data.

In the following sections of this paper, the *Internal CL Interface I-CL* and the *External CL Interface E-CL* (bold black arrows) will be discussed in detail. The *I-CL* and *E-CL* interfaces are provided by the *CL*. The *CL* itself was implemented using the OSGi framework [9]. OSGi provides several proven mechanisms for modularity, inter-process communication, notification, and scheduling. The communication between intra-component bundles relies on the OSGi event handling mechanism communicating Java objects as well as specified parameters in OSGi events. It must be noted that the data layer interfaces are specific to each use case or demonstrator site and therefore cannot be easily standardised. They are therefore beyond the scope of this paper.

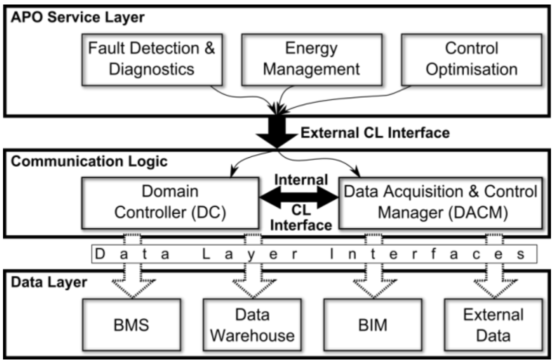

Fig. 1 *The high-level architecture of the BaaS system*

3.2 Interface Design

One of the objectives of the BaaS research project is to develop standardised interfaces for building energy management purposes. In order to create such interfaces, readily available technologies, such as REST and XML, are used for the inter-component communication whenever possible. The main difference between the *I-CL* and the *E-CL* is that the former is used by only two components (i.e. the *DC* and *DACM*) so that the required properties of the interface can be clearly specified whereas the latter, offering *CL* functions to components outside the *CL*, can be accessed by a variety of components living in the *APO-SL* which may not even be known at the time of writing the interface specification.

Thus, in order to make the interface design, particularly that of the *E-CL*, as generic and versatile as possible, standard functions (such as *RetrieveLiveBMSData* or *StoreOptimisationResults*) are specified which are assumed to have been designed sufficiently universal to meet the requirements of all use cases. Any *APO-SL* component can access these functions via the *E-CL* if the interface is properly implemented. The decision to use open standard technologies for the interfaces *I-CL* and *E-CL* allows implementers of the different layers (*DL*, *APO-SL*) and components (*DC*, *DACM*) to choose freely from large range of available technologies. This is particularly interesting in a multi-vendor environment like the building industry where different suppliers provide the various parts of the BaaS platform.

For ease of implementation of the BaaS prototype, the inter-component communication, both locally and across different IP networks, is based on the REST architecture and its GET, PUT, and POST commands. The actual data to be transmitted is encapsulated in XML; the XML message structure of *I-CL* and *E-CL* closely reflects the data structure of OSGi events, i.e. carries an event topic string and a set of event properties as payload. This way, the *I-CL* and *E-CL* definitions followed directly from the communication needs of the components' OSGi bundles and allowed the definition of an algorithm to convert between XML messages and OSGi events in a generic way.

4 Demonstration Sites

To test the scope of the BaaS middleware in a realistic context, a building in Valladolid, Spain is used for reference implementation. The Fundacion CARTIF (Valladolid, Spain) building is a 15 year old building, in which – besides the conventional HVAC systems – there are several renewable energy sources. CARTIF has a BMS based on LonWorks, a live database based on postgreSQL, and a weather station as main data sources. Due to size restriction, the illustration how the BaaS middleware implements the interoperability concept in CARTIF building is beyond the scope of this paper. Other demonstration buildings include a university in Greece and a research institute in Germany.

5 Outlook

It is envisaged to implement a common data model for all types of data that are encountered (BMS readings, BIM data, BMS control commands, schedules, occupancy data, etc.) as unique vocabulary to be used in the entire BaaS system. All BaaS software components and interfaces communicate with each other using the same data scheme. Furthermore, deploying the data model beyond the Baas system (data sources as building information repositories or databases) is expected to allow seamless interoperability not only in the operational phase but throughout the whole building lifecycle.

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