Number 92, January 2013

ERCIM NEWS

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Smart Energy Systems

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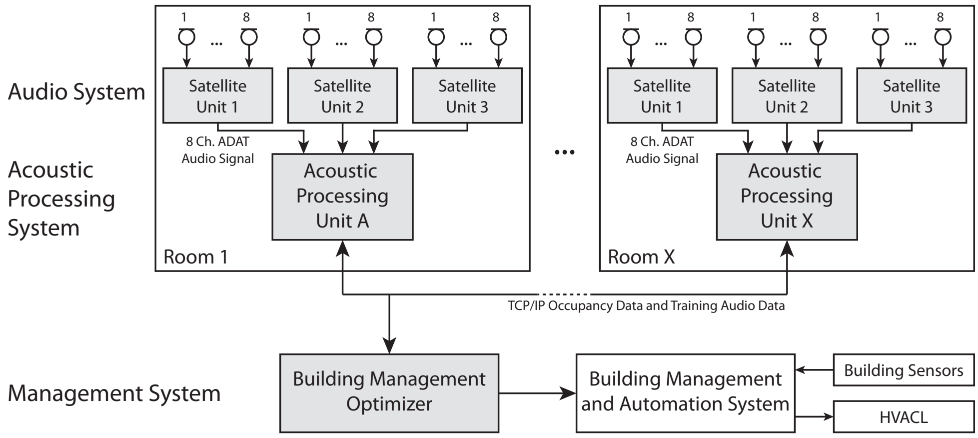

Figure 1 system components for the S4EeB project

All the data and semantic information from the APU are collected and analyzed by the building management system optimizer, which is the interface to the "classic" building management system. Based on the building's occupancy rate, its thermal characteristics, outside weather conditions, and other parameters, the optimal settings with respect to energy efficiency and user comfort will be determined. Thermal modelling of the building is done beforehand, providing the basis for the best strategy considering the building's energy consumption rate and the interaction of the building management and automation system with the HVAC system.

The main contributions of Fraunhofer IDMT to the project are: sound recording, audio signal processing, and acoustic event detection. In particular, audio data captured is analysed by algorithms developed by Fraunhofer IDMT, allowing the building's occupancy rate to be determined for the purpose of integrating this data into the building energy management system.

This three-year project is funded by the European Union, and its consortium comprises research institutes and industry partners from four European countries, who have long-standing experience in building control strategies, audiovisual applications, microelectronics and mechanical components as well as in consulting and dissemination of results. The project recently finished its first year of collaborative development of a prototype system and the corresponding components. In the first quarter of 2013, field tests will start at the S4EeB demo sites, namely Milano-Linate airport and two shopping malls in Spain, Principe Pio in Madrid and Maremagnum in Barcelona.

Links:
http://www.s4eeb.org
http://www.idmt.fraunhofer.de

Reference:
[1] P. Bertoldi and B. Atanasiu: "Electricity Consumption and Efficiency Trends in the Enlarged European Union", European Commission, Institute for Environment and Sustainability, 2007.

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Ambient Intelligence for Energy Efficiency in a Building Complex

by Giuseppe Lo Re, Marco Ortolani and Giuseppe Anastasi

The quest for energy efficiency currently represents one of the most stimulating challenges both for academic and industrial organizations. We address the issue of ensuring timely and ubiquitous monitoring of a potentially large building complex in order to optimize their energy consumption.

Over 50% of energy produced worldwide is consumed by the industrial sector, whilst residential and commercial buildings account for about 20%, mainly due to inappropriate use of appliances, such as heating, ventilation and air conditioning (HVAC) systems and artificial lighting [1]. Hence, the International Energy Agency's (IEA) roadmap has set the goal of reducing energy consumption by HVAC systems by 30% and 17% in residential and commercial buildings respectively by the year 2030. Similarly, the goal is to reduce energy consumption by artificial lighting by 3% and 14% for residential and commercial buildings respectively [2]. Consequently, recent years have seen a growth in research on energy efficiency in residential/commercial buildings.

Studies show that providing appropriate feedback to building occupants can help reduce overall energy consumption, but in the long term this is not an effective approach [3]. Using an automated Building Management System (BMS), in addition to user cooperation, is a more viable solution, especially in the context of ambient intelligence (AmI). AmI is a new paradigm in Artificial Intelligence that relies on the assumption that the environment is permeated by a set of sensors and actuators, remotely controllable according to some policy, in order to bring the environmental conditions closer to the user's ideal conditions while taking into account particular global constraints.

Within the "SmartBuildings" project, we are currently designing and prototyping an AmI-based BMS targeted to a building complex (eg, a campus or a residential complex), rather than just a single building. In our approach, the remote sensor infrastructure acts as the termination of a centralized reasoner, where sensed data are processed to extract higher-level information and perceive high-level features such as who is in a specific area or what this person is doing there (eg reading, talking, standing). Finally, a set of actuators modifies the environmental conditions.

Our system architecture has been conceived to guarantee the scalability of the proposed solution with respect to the number of buildings to be monitored and the number of different devices to be used. In order to efficiently organize the system modules, each corresponding to a different logical task, we chose a three-tier architecture as a model. The physical layer consists of sensors and actuators; the middleware layer defines a set of AmI components that can be composed to implement intelligent AmI functionalities; the application layer allows for applying the monitoring and controlling rules in compliance with energy constraints.

From the viewpoint of deployment, the building premises constitute the basic monitored units of our system, where the sensor and actuator networks are installed. These networks are heterogeneous both in terms of the adopted technology and of the performed monitoring/actuating tasks. Several basic monitored units are coordinated by a BuildingAgent, responsible for performing reactive control and further data aggregation. Small buildings will have a single BuildingAgent per building, while medium or large buildings could have more. In our vision, an individual building is part of a community coordinated by a central orchestra leader, the AmIBox (see Figure 1). The latter ensures coherence of the adopted energy saving strategy, besides providing high-level AmI functionalities, performing intelligent reasoning and choosing the adopted energy saving strategy. The AmiBox could also take into account externally imposed constraints, such as those arising from the connection with an energy provider's Smart Grid infrastructure.

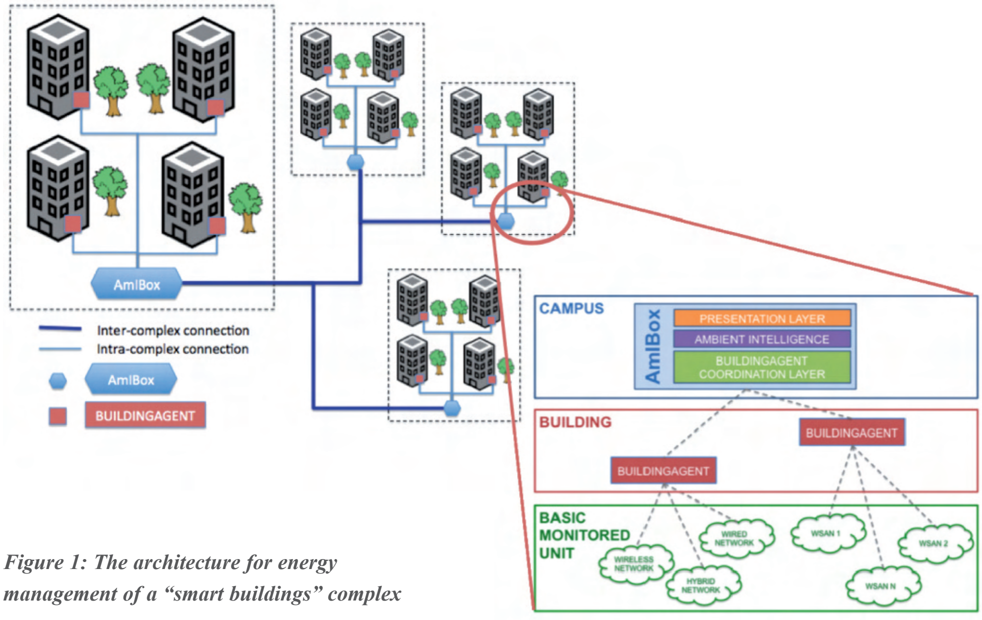

Figure 1: The architecture for energy management of a "smart buildings" complex

The project is currently in progress. We have already deployed a minimal prototypal setup, by equipping one floor of our department with commonly available sensor nodes for monitoring the typical environmental quantities (temperature, humidity, light) and with the corresponding actuators. Moreover, we are able to monitor the globally consumed energy through a remotely controllable power meter. The research group operating at the Lab of Networking and Distributed Systems (Univ. of Palermo) is currently focusing on the design of core intelligent functionalities, such as user profiling, predicting the occupancy status of the monitored premises, or detecting the activity patterns of users, that will form the basis for subsequent intelligent reasoning. For instance, we have developed a Bayesian inference system for multi-sensor data fusion in order to reliably infer the presence of users from the available sensory information. Probabilistic reasoning accounts for the partial correlation between sensory signals and states, and allows the system to cope with noisy data, while the possibility of integrating data coming from multiple sensors exploits the redundancy of such devices deployed throughout the environment. In order to reduce the costs of the overall system and limit its intrusiveness, the number of sensors should be kept as low as possible. To this end, the research group operating at the Pervasive Computing and Networking Lab (Univ. of Pisa) is investigating the use of advanced methods for extracting individual consumption estimates from aggregated measurements.

This research is part of the "SmartBuildings" Projects funded by the Sicilian regional Government with European funds.

Link: http://www.dicgim.unipa.it/~networks/ndslab/

References:

[1] U.S. Energy Information Administration: "International Energy Outlook 2010 – Highlights", report DOE/EIA-0484(2010), http://www.eia.doe.gov/oiaf/ieo/highlights.html

[2] International Energy Agency, 2011: "Technology Roadmap, Energy-efficient Buildings: Heating and Cooling Equipment", http://www.iea.org/papers/2011/buildings_roadmap.pdf

[3] X. Jiang, et al: "Experiences with A High-Fidelity Wireless Building Energy Auditing Network", in proc. ACM SenSys 2009.

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