GreenerBuildings

An ubiquitous embedded systems framework for energy-aware buildings using activity and context knowledge

GREENERBUILDINGS develops an integrated solution for energy-aware adaptation of public buildings. It investigates self-powered sensors and actuators, occupant activity and behaviour inference, and an embedded software for coordinating thousands of smart objects with the goals of energy saving and user support.

KEYWORDS: activity recognition, distributed control systems, ubiquitous computing.

At A Glance: GreenerBuildings

Acronym An ubiquitous embedded systems framework for energy-aware buildings using activity and context knowledge

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Main Objectives

Buildings account for more than 40% of energy consumption and are the largest CO^2 producers in many world regions. Thus, making efficient use of energy in buildings is paramount to conserve energy and reduce greenhouse effects. To date, automated control and adaptation in buildings is often limited to occupant commodity changes of indoor climate depending on room temperature, CO^2, and lights operated though motion detectors. GREENERBUILDINGS aims to realise an integrated solution that addresses the challenge of energy-aware adaptation from basic (energy harvesting) sensors and actuators, up to an embedded software for coordinating thousands of smart objects with the goals of energy saving and user support.

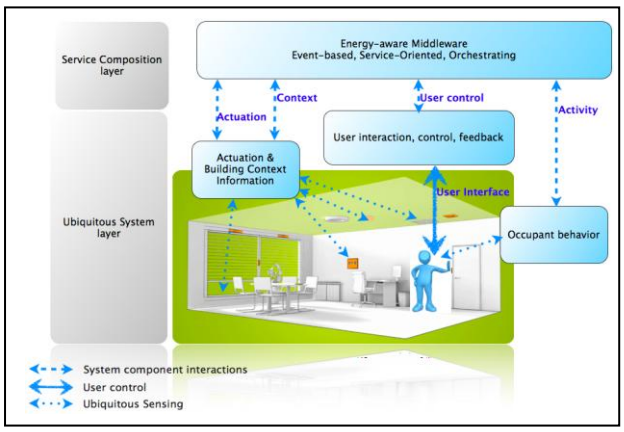
GreenerBuildings will investigate how buildings can dynamically adapt their operations according to actual use, aiming at substantial energy savings.

Our vision is that buildings can respond to their actual use and changes in their environment; interact with their occupants through novel ubiquitous sensing and occupant behaviour inference techniques and that can transparently adapt a building's function and operation. The project embraces the following key principles in order to achieve its goals: (I) living lab experimentation and validation scheme, (II) an agile cross-domain consortium, (III) a spiral development model, and (IV) a user centric approach. In particular, the validation will consider test cases with at least 1.000 devices (sensor and actuator nodes) deployed in living lab buildings. Public buildings, such as offices, universities, hotels, and shops will be considered. With its multi-national consortium, the project's outreach will go beyond European boarders.

Technical Approach

GREENERBUILDINGS aims at developing an energy-aware framework based on embedded service middleware and a building-distributed architecture of smart objects. The framework relies on advances of ubiquitous ultra-low power sensing, sensor-based human activity recognition, and device orchestration, to guarantee responsiveness, scalability, and dependability in its goal to achieve energy savings at the whole building level. The key to effective energy management in buildings depends on several functions, most notably, low-maintenance activity and building context sensing, robust recognition and sensor-based inference, and the framework's scalability to massively distributed installations. GREENERBUILDINGS addresses these functions in its technical architecture and allows retrofitting all solutions into existing buildings.

The GREENERBUILDINGS architecture specifically emphasises occupant activity and behaviour as key element for adaptation, but addresses other building context information as well. The building adaptation concept foreseen in GREENERBUILDINGS follows a layered representation to decouple different abstractions.



Ubiquitous system layer. This layer consists of physical devices, in particular the building-distributed ubiquitous sensing, processing, and actuation architecture of GREENERBUILDINGS. Moreover, it consists of the occupant activity and building context recognition functionalities. These smart objects are physically distributed to support the sensing and actuation tasks. At the same time, nodes interact to perform operational adaptations.

Service composition layer. This layer comprises the abstract composition and orchestration functionalities of the energy-aware framework. Services in the GREENERBUILDINGS architecture are dynamically composed to achieve the energy optimisation and user goals, using triggering events and state change information provided by the ubiquitous system layer's sensing nodes and user interactions.

Key Issues

Ambient intelligent environments such as those targeted by GREENERBUILDINGS require ubiquitous sensing nodes that can be conveniently deployed and operated for extended time periods (several years) while requiring minimal or no maintenance effort. Novel effective sensing concepts need to be developed that are cheap when mass-produced, permit rapid installation and, in particular, are not constrained though power supply or battery life. This new class of smart nodes will be investigated and validated through deployments in living-lab buildings. Based on limited and potentially confusing sensor input, relevant knowledge on actual occupant behaviour must be obtained to adapt building installations and appliances. Novel model-based behaviour descriptions and occupant group behaviour estimation algorithms will be investigated and complemented with thermo-dynamic simulations of building spaces. The cooperation among the heterogeneous smart objects and devices will be facilitated and mediated through the distributed framework with the additional constraint of being energy efficient. Besides the evaluation of actual energy-saving potential, which is to date only estimated through coordinated manual trials and simulations, the comfort and convenience for occupants will be assessed.

Expected Impact

Near future buildings will include thousands of cheap sensors, actuators, and smart devices that collaborate with each other in a distributed manner, aiming at increasing the level of comfort and safety of the inhabitants. This trend is growing stronger and opening a number of interesting technological solutions, where energy preservation takes an essential role to realise more efficient buildings.

The expected main impact of GREENERBUILDINGS is to develop an infrastructure that is energy-aware and conservatory, while at the same time fully exploit the potentials and advantages of intelligent buildings, with large-scale networks of collaborating, intelligent devices and sensors. Most immediately, GREENERBUILDINGS will realise improvement in the energy-efficient operation and usage costs of individual nodes (local), and an advanced control and cooperation mechanism to reduce the overall consumption (global).

In large buildings, centralised control of all operations will be infeasible due to its complexity. However, adaptations of local settings in a room, and global building operations can impact energy consumption. Thus a mixed local and global strategy will be investigated, which will form a founding infrastructure to realise truly greener buildings.