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APPLYING DIGITAL SMART TECHNOLOGIES FOR A SUSTAINABLE ARCHITECTURE

Pervasive computing allows the design of sustainable architecture.

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Abstract. One of the major advantages of *'pervasive computing'* is its positive sustainable impact. This paper introduces an approach for architectural design related to 'pervasive computing', which is named 'future ready'. It is a discussion on the sustainable impact of pervasive digital devices within architecture. It illustrates its idea, its application and evaluation and shows examples from Europe and Asia.

1. Introduction

Sustainability through computers is not new. In the 1970s, innovative approaches mentioned, that computer infrastructure allows the reactivation of old buildings (Moersch, 2006). This was the first sustainable impact of computers in this field. The second impact starts right now.

During the period of 4 years, the work at the Chair of CAAD at the Swiss Federal Institute of Technology (Building IP, 2006) focused in research, prototypical installations and teaching on computer integrated buildings.

The building is seen as an information system (Schmitt, 1999). The architect is seen as the main mediator within specialists in pervasive computing. And, pervasive computing has great potential for a positive sustainable impact.

1.1. GUIDELINE FOR DESIGNING COMPUTER INTEGRATED BUILDINGS

In order to bring pervasive digital technologies into the known articulation of architects, two main definitions were introduced:

1. 'future ready design'
2. 'digital material'

'Future ready design' summarizes major intentions of a design in the digital age, such as: enabling and supporting changing activities on the level of rooms, networked building control on the level of apartments/offices and houses. The results of this guideline are designs with flexible usage and lower expense of operation for the client. The guideline can increase living comfort and the same time reduce energy consumption - a contribution towards ecological and social sustainability.

'Digital material' aims for the perception of 'pervasive computing' as a collection of decision taking parameters equivalent to known materials such as reinforced concrete, wood and glass. This view allows the architect to handle the constrains of pervasive digital systems (technology and resulting services) equal to constrains of material, laws, structural calculations, etc. The research in this filed is still going on.

2. Evaluation

The following projects, demonstrations and concepts evaluate the principles 'future ready design' and 'digital material':

2.1. HOUSING PROJECT IN CHINA

Size of a project and the rules of the real estate markets are both tough but good fields in order to evaluate principles. For a housing project in Beijing, PR China, an investment company initially asked for 'smart apartments' in order to attract publicity. 966 apartments were finally designed. In the beginning, the meaning of 'smart environment' was the one given by the industry: large LCD-screens and 'smart' refrigerators.

During discussions with the client, marketing experts, architects and engineers, the sustainable power of smart technologies was introduced and seriously calculated in relation to investment/savings. Amazingly the idea of sustainability attracted attention in currently booming and fast pacing China.

Calculations by experts show, that the energy consumption of the houses can be reduced up to 15% when using state-of-the-art technology and modular software. This applies already by simply networking control, production and distribution of heat and cooling energy (see figure 1).

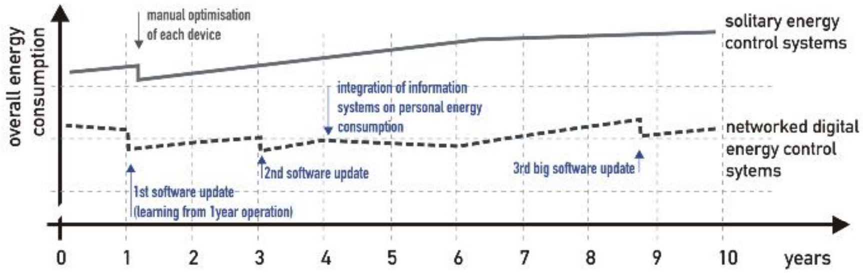

Figure 1. Schematic diagram on the difference of energy consumption over time (solitary vs. digitally networked system).

From the very beginning, all parties that were involved agreed on consequently using TCP/IP-enabled devices combined with cross disciplinary software on all scales. Scales means in this context: from light-switch to multimedia-distribution, access-control, ventilation, local energy distribution, central power plant, municipal energy supplier and Internet based data.

The engineers accepted the architect as the central coordinator in this rather technical design process (see figure 2). Experts in building services networked all sort of different services through TCP/IP-enabled devices. Finally the investor accepted higher initial building costs in order to have more attractive buildings to sell and lower operation costs (equals higher profit). The team worked out a system closely related to Frank Duffy's (Strehlke et al, 2004) vision of the computer integrated building.

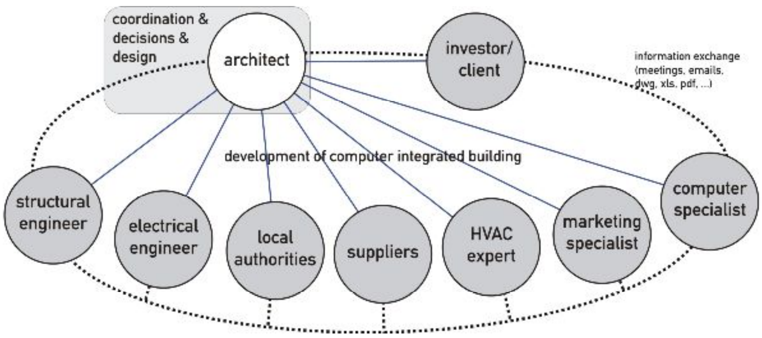

Figure 2. Interdisciplinary development of the networked building system with the architect as central coordinator and designer.

Networked sensors and actors are connected through TCP/IP, independent of the manufacturer and their internal protocols (see figure 3). The more areas of the building-services are networked, the higher the number of software based services will be integrated (Mitchell, 2003). Peaks in energy consumption are tried to be avoided. Energy peaks are the main factors for high energy consumption and high costs.

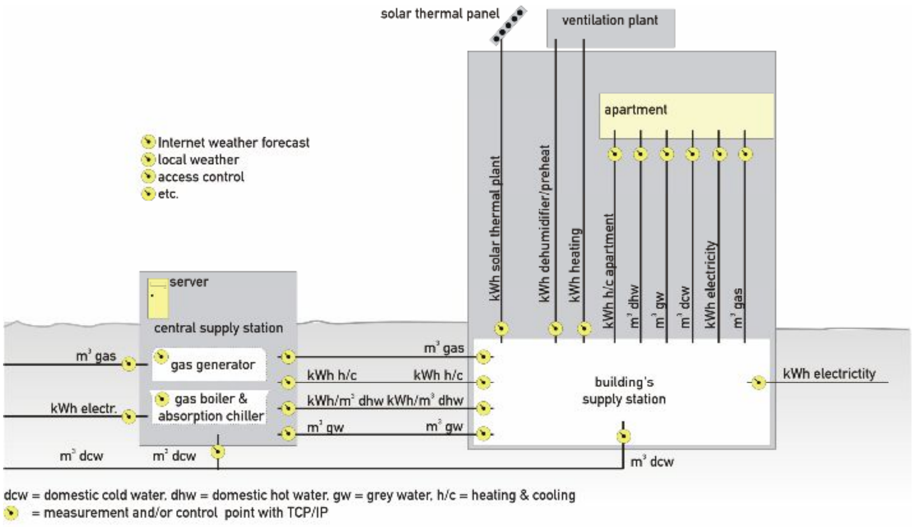

Figure 3. Topology of digitally networked sensors and actors all connected to a central server.

2.2. UPGRADE OF NATIONAL MONUMENT INTO A STATE-OF-THE-ART THINK TANK AND CONFERENCE HOTEL

Located in a rural region of Switzerland, two buildings are use for conferences and brainstorming by our university. The two buildings are: the so called 'Villa Garbald' - a 140 years old national monument and the guest-house - a three years old building awarded the best architectural object in 2004 in Switzerland. The buildings provide state-of-the-art infrastructure such as broadband internet connection and full access to the universities digital library and interactive furniture for collaborative work.

The old building is a successful example of a reverse 'future readiness' - the functional flexibility of almost any building through digital technology. By integrating digital technology even for simple services such as doorbells, original wall paintings and surfaces did not need to be destroyed. Calculations show that 30% less cables were needed to be implemented for light control by simply using a digital bus system.

Sustainability is observed: i) the old building can be used with contemporary functions and therefore will not decay or be torn down. It offers old-style atmosphere *and* state-of-the art work environment. ii) protection of the existing structure iii) networked temperature sensors monitor the indoor climate and give alarm by email iv) extended period until the next physical renovation because of changing requirements.

Figure 4. left: The conference hotel with the old and the new building. center: Installation of a tiny webserver for light control in the doorframe. right: View in the 'pervasively computed' room - contemporary use in original old ambience.

2.3. ETHWORLD LECTURE HALL OF THE FUTURE AND DIGITAL DOORPLATE

Within a major project at our institute, we researched and evaluated the possibilities of digital and networked media in academic teaching.

As soon as lecture hall becomes computer integrated, the room can host services such as: remote lectures, automated recording, telerobotics (Goldberg, 2000) and broadcast services. Further on, the period until the next physical renovations would take place is extended. Immediate 'renovations' are possible and simply done by updating the control software (Mitchell, 2003). Within seconds new services will be integrated - without a single structural change. A major advantage is that software can be copied among all lecture halls instantly and free of charge.

The possibility of an optimized spatial logistics was a main finding when developing a networked digital doorplate for the school's rooms. Its sustainable aspect is of relevance. By connection location based information with the school central curriculum, we found out there was permanently one lecture hall out of use. Electronic screens would allow the instant reaction on peak situations.

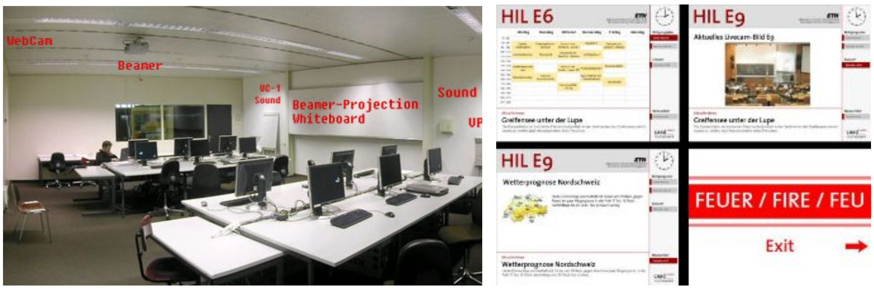

Figure 5. *left: V*iew into the upgrade ‚smart lecture hall of the future'. right: Screenshots of the digital doorplate that enable optimised use of the infrastructure and introduces sentient systems (e.g. events, location based fire escape warnings, etc.).

2.4. SENSOR FACADE

Buildings consume a high amount of energy. In Switzerland appr. 50% of the overall primary energy is used by buildings (Faktor, 2006). Small adjustments lead to significant lowering of energy consumption and costs.

During a demonstration at the 'European Workshop on Wireless Sensor Networks 2006' (EWSN, 2006) the author set up a demonstration in collaboration with industry partner 'particle computer GmbH'. In this demonstration, a fine granular system for monitoring relevant physical parameters of a building both indoors and outdoors was presented. 'Particle computers' provide battery-powered computers in thumbnail size and wireless connectivity. Embedded sensors measure temperature, light intensity and movement. Once the data is collected, it can be analyzed for future trends in building control and to dynamically react to internet based weather forecasts and special events. (sensorfacade.net, 2006).

Figure 6. left: A ‘particle computer’ with integrated sensors and wireless connectivity. right: Illustration of the sensor network attached to a facade.

3. Findings

a. pervasive computing supports sustainable approaches in architecture.
b. the systems, topologies and concepts chosen proof great flexibility of activities inside the buildings now and in mid term future.
c. a main backbone based on TCP/IP allows fast and powerful planning with all involved disciplines, flexibility and independency of suppliers. Additionally TCP/IP based systems save operational costs.
d. pervasive computing allows easy reconfiguration during long term use.
e. the architect regains control in a mainly technical field.

4. Conclusion

The authors consider the chosen approach to be highly innovative in terms of sustainable designs. Formally the resulting architecture doesn't follow any ecological design. Inhabitants and investors are directly noticing these advantages e.g. by extended renovation-cycles or lower operation costs. With the intrusion of small digital devices into the building, an amazingly direct link towards sustainability is possible.

5. Outlook

Soft services such as instant information of the inhabitants on the current energetic well behavior of the building will be a main issue for future work. This is in order to teach the inhabitants in low energy consumption. It would be the extension of Negroponte’s statement to teach computers to see and hear in the meaning of teaching buildings to see, show and talk (Negroponte, 1995).

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