Housing and information society: integration of ICT in the existing housing stock

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ABSTRACT:
This paper describes an ongoing research concerned with the insertion of technology in domestic spaces, and more specifically in the existing housing stock. The study evolves with the premise that the insertion of technology in domestic spaces can reduce energy consumption and the environmental impact, in general, of the use and functioning of buildings, while contributing for improving the quality of life of its inhabitants. It also considers that the rehabilitation of existing buildings and urban areas is preferable to the construction of new housing, if one is concerned with the environmental impact of construction activity in the city. The study focus on the buildings built in Lisbon during the period 1950-1970 which accounts for a considerable part of the existing housing stock. The goal is to identify the strategies to follow in the refurbishment of these buildings so that they fulfill the requirements of modern life. The strategy should specify the level of technology to incorporate considering the profile of the targeted households.

1 CONTEXT

This paper describes a Ph.D. research that is currently being developed at Instituto Superior Técnico (IST) and at the National Laboratory for Civil Engineering (LNEC) on the subject of "Housing and Information Society: study for the integration of Information and Communications Technologies in existing residential areas". It builds on a preliminary project called "Housing for the future" which was developed at LNEC a few years ago.

The Ph.D. thesis sets off with the premise that the future of real estate market in Portugal will require the rehabilitation of existing residential areas and that it will be of utmost importance the incorporation of Information and Communications Technologies (ICT) in the quest for added sustainability, social integration, support for elderly and people with reduced mobility, and in the improvement of quality, comfort, and adaptability of housing.

2 PROBLEM

In an era in which information and energy have structural roles in society, it is herein proposed a reflection on the transformation of the ways of life occurred over the last decades and his impact on the demand of new housing functions and types. The incorporation of new housing functions calls for a new approach to the design of domestic space, in which the diversity of conventional spaces must interact with the inclusion of new multifunctional spaces that accommodate activities such as telework and telehealth in order to respond to the growing demand of information access and of comfort in homes.

In addition, it is hereby acknowledged that the construction industry is, of all human activities, the main responsible for energetic consumption, and therefore, it is necessary to reduce the

negative environmental impact of buildings both in the sheer construction, in maintenance, and in rehabilitation.

Considering that Lisbon has a high percentage of vacant housing, and that the existing housing infrastructures are sufficient to respond to the housing demand in the city (vide Table 1), the problem that concerns us is how to rehabilitate existing buildings and supply them with the specifications that fulfill the contemporary needs of comfort, homeliness, and information access, among others.

3 HYPOTHESIS

Lisbon's resident population has been diminishing at a fast rate, currently amounting to 564,000, after having dropped 14.9% in ten years time (INE 2002). The loss of resident population has been followed by a progressive degradation of the city's housing infrastructure with the consequent growth in the number of the vacant houses.

The extent of the vacancy problem is illustrated by the fact that the full occupancy rate of the existing, under construction, licensed and planed housing is of over 930 thousand habitants (Pinho 2005).

As shown in Table 1, the vacant house figures in 2001 were a considerably superior to the housing shortage in the city. In fact, 9% of Lisbon's housing is utilized for seasonal residence and 14% is vacant (CML 2002). In addition, 51% of the traditional residences in Lisbon are occupied under capacity and only 16% are filled over capacity.

Table 1 – Housing quantity deficit and vacant housing by NUTS II, Lisboa, 2001. (Rodrigues 2002)

	Portugal	Lisbon
Unconventional housing	27,319	11,960
Traditional families resident in hotels and in communions	8,178	1,981
Shelters for families residing is shared occupation methods	68,299	21,376
2% of the traditional resident families	73,015	20,113
Total deficit	176,811	55,430
Vacant housing	543,777	149,327
Vacant housing available in the market	185,509	58,403

The above figures suggest that more than the construction of new buildings we need to rehabilitate existing ones. However, in 2002, the activity of conservation and rehabilitation in Portugal represented a mere 6% of the construction trade (the european mean was 37%) (Aguiar 2007). Statistics indicate that, although rehabilitation is now a very popular subject, new construction continues to largely dominate the housing market.

The reduction of the environmental impact of buildings inevitably calls for the rehabilitation and reutilization of existing infrastructures. This fact seems to be well accepted by the consumers, but is not echoed by the construction industry, which seems ill prepared for responding to such a demand. It is not uncommon to find plans for urban renovation with conversion of use in historical areas that are advertised as urban rehabilitation, while focused on sheer maintenance of building facades, while destroying all of its interiors to construct new structures., These plans are purposefully misleading as they attempt at taking commercial advantage of public interest in sustainability and heritage conservation.

The construction industry is the main responsible for energy consumption and it is, therefore, necessary to reduce the negative environmental impact of buildings. The construction process has a huge negative impact on the environment for it consumes and uses up considerable natural resources. Construction alone, on the one hand, generates the emission of polluting agents and, on the other, creates waste that to be processed requires, in turn, more consumption of resources. This consumption cycle proceeds during the use of the building and it aggravates itself

towards the end of its lifespan. Not only does this phenomenon occur at the building level but also at the city level (Mourão 2005).

The use of ICT and of domotic in the dwelling use and maintenance period may also contribute for a reduction of the environmental impact of buildings. Domotic may protect the environment by optimizing the processes involved in use and maintenance to allow a more rational use of natural resources, such as energy and water, and a more rational set up of the inhabitable space. The most common domotic specifications and systems that favor energetic efficiency of the building are energy management, blinds control, lightning control, heat and cooling systems control, automatic ventilation control and the use of ICT to remotely control the house and energy the consumption.

4 OBJECTIVES AND METHODOLOGY

The ongoing research has the following objectives:

- Studying and defining the functions of housing in the current Information Society (IS), through the analysis of the impact produced by the integration of ICT in the dwelling space, both on spatial and functional organization, and building methods;
- Determining the adequate set of ICT to incorporate in the dwelling spaces, so that it values sustainability and the social integration of citizens, while making it possible to progress towards a fine tuning of solutions, adapted to each household, according to its present and future needs. Such set of ICT would be applicable to the dwelling as well as the building, not only in new construction but in the existing residential areas's rehabilitation as well;
- Defining design guidelines to support architects in the adaptation of existing residential areas with the purpose of ICT incorporation, thereby allowing those professionals to balance new dwelling trends with sustainable requirements and economic feasibility.

The first stage of the research was concerned with a literature survey of studies on the effects of architectural transformations that are emerging as a result of new ways of living that imply increasing housing requirements. Out of the aforementioned requirements, emphasis will be given to the ICT impact on spatial and functional organization caused by telework and the need to attend to a growing number of seniors and people with reduced mobility.

The ICT also has impact on construction, since the increasing requirements of information access and comfort in housing have called for new changes in the building's image as well as in the ways of thinking and defining the basic infrastructure. The necessity of networks and information systems that require physical space to run the cables between components of the domotic system, together with the tendency to make the housing spaces more flexible and adaptable, demand different construction solutions that require study.

The second stage of the research aims at identifying the adequate set of ICT to incorporate in, a dwelling considering its household profile.

Due to the fact that there is no single technological solution that fits all, it becomes necessary to define an adequate set of ICT and domotic that can be integrated in each home and that promotes environmental sustainability and social integration of its inhabitants. In addition, the set should be able to adapt to the evolution of the household. This issue will be addressed first by considering several households and then by identifying the corresponding patterns of ICT.

The study will use as a case study a specific housing stock in Lisbon, to make it possible to:

(1) To gather data referring to the current housing types, its spatial and functional organization, and its building characteristics;

(2) To assess existing problems:
   - *(a) at a functional level, by matching the spatial and functional patterns proposed in the original project, with current requirements when articulated with the introduction of ICT and domotics in housing.*
   - *(b) at a building level, by matching existing building characteristics and infrastructures with present needs, namely as far as ICT are concerned.*

(3) To propose generic solutions that satisfy current demands and that may be applied to other similar buildings.

Due to the large variety of buildings that require rehabilitation in Lisbon, it was necessary to select a specific stock to use as a case study. The housing stock built in the 50's and 70's of the last century was chosen on account of what it represents (circa 36% of Lisbon's buildings were constructed between 1946 and 1970 – vide Table 2) and its expectancy of rehabilitation in a short term. According to the 2001 census, 55% of the buildings constructed in Lisbon between 1946 and 1970 needed improvement repairs, and 24% was considered to be in medium to highly deteriorated conditions.

Table 2 – Housing according to the period of construction. (CML 2002)

Period of construction	Lisbon
Built before 1919	18,28%
Built between 1919 e 1945	23,66%
Built between 1946 e 1960	22,01%
Built between 1961 e 1970	14,21%
Built between 1971 e 1980	8,96%
Built between 1981 e 1985	2,73%
Built between 1986 e 1990	2,94%
Built between 1991 e 1995	3,17%
Built between 1996 e 2001	4,04%

Table 3 – Conventional housing according to occupation form in the period of construction between 1946 and 1970. (CML 2002)

Occupation form	Lisboa
Occupied – usual residence	79,97%
Occupied – seasonal or secondary use	8,80%
Vacancy – for sale	0,94%
Vacancy – for rent	2,22%
Vacancy – for demolition	0,23%
Vacancy – others	7,84%

The type of building that was chosen is commonly labeled tenement building" (subsequent to the 2nd world war) and it presents a "right and left" displacement (vide Figs. 1-2), variable heights with a four-flour average, and a preponderance of reticulate concrete structure filled with masonry walls.

In the two decades that this study concerns, it was observed a slow increase in the height of buildings, as well as the employment of new construction techniques and the increasing use of concrete[1].

The type emerged in Lisbon after 1951, when the General Regulation of Urban Buildings (or RGEU) was created, and it influenced the 1967 Regulation of Concrete Structures (or REBA) and its subsequent revised regulation, approved in 1983, called Regulation of Reinforced and Pre-stressed Concrete Structures (or REBAP).

The dwellings are essentially very similar to each other, and present mainly two and three bedroom layouts, with relatively small, highly split areas.

[1] According to the 2001 census, 46% of the buildings built between 1946 and 1960 have a concrete structure, and in the period between 1961 and 1970, the figure rises to 63,1% (INE 2002).

Fig. 1 - Multi-ocuppancy habitational building in Lisbon, Av. de Roma, decade of 1950.

Fig. 2 - Multi-ocuppancy habitational building in Lisbon, Bairro de Alvalade, decade of 1950.

5 REHABILITATION AS A SUSTAINABILITY STRATEGY

The city of Lisbon needs to reassess its housing policy so that the main concern becomes to rehabilitate the existing housing infrastructure rather than constructing new buildings.

As mentioned above, the high number of vacant buildings and houses in the city, along with the fact that they have already restrained the use of the soil and usually have a long-term use expectancy, are good and undeniable reasons why the addition of houses should preferably be made by the rehabilitation of old ones (both function wise and construction wise) and the reutilization of the existing infrastructure.

The reutilization of existing buildings contributes for urban sustainability, since it renews, regenerates, and rehabilitates the city.

To reclaim residential use for the city's downtown allows the regeneration of urban areas, while bringing new population to the center, making the most of the existing infrastructures, making proper use of the already conditioned soil, and reducing voids in the city, thereby endorsing full city occupancy.

From a financial viewpoint, rehabilitation also reduces investment because of the exceptionally high value of land for new residential buildings prevalent within cities.

According to Daniels (2000), *"transport is the next major consumer of energy after buildings."* Hence, drawing new population to the city center is a factor that endorses the existing transportation infrastructure use while reducing the distance between home and the work place.

The major drivers for rehabilitation are the following: it is a viable solution to the need for complying with high environmental standards, it overcomes the scarcity of available land in the city, it depletes renewable and non-renewable resources (materials, water and fuel) to a lesser extent, and it reduces the waste in construction by reducing demolition.

6 FUNCTIONAL REHABILITATION OF LISBON EXISTING RESIDENTIAL AREAS

Although the existing housing stock in Lisbon has the potencial to draw more population to the city, the truth is that 55% of dwellings built in the studied period requires construction rehabilitation (INE 2002). The need to rehabilitate these dwellings from a functional perspective is also vital, but perhaps not as easy to quantify as it is to understand.

The existing housing stock does not fulfill the present lifestyle's needs, both function wise and comfort standards wise. The selected housing stock, now a few decades old, present several problems that jeopardize its functional and constructive performance, particularly in terms of comfort. This situation is the result of a set of factors, of which we underline the following: lifestyle changes that demand new needs and requirements; and the inexistence of regular repair works, which cause deterioration of materials, components and utilities.

One premise of the current study is that the functional adaptation of houses to new ways of living and to the diversity of current needs and requirements can be facilitated by the incorporation of ICT and domotic. The rehabilitation concept that is herein supported involves the conservation of rehabilitated buildings and the incorporation of ICT for adaptating its use to the demands of today's Information Society.

Over the last decades, social and technological changes have affected the ways of living and the requirements and functions of housing. These have changed the families' lifestyle, thereby making traditional house types inadequate to the contemporary society's demands. Although the concept of family unit still represents the majority of homes, the crescent number of other forms of cohabitation and new ways of grouping individuals cannot be ignored.

The integration of new functions in homes calls for new approaches to the design of domestic spaces, in which it is necessary to incorporate the diversity of conventional spaces to the multiplicity of new-functions created by the emergence of activities like telework.

In addition, the technological dependence that characterizes the current civilization, along with crescent demands of access to information and comfort, claim for the incorporation of a set of support infrastructures in the dwellings.

7 INCORPORATION OF ICT AND DOMOTICS IN THE REHABILITATION OF EXISTING RESIDENTIAL AREAS

Home networking and automation systems can have a very important role in contemporary dwellings because of the benefits they bring to residents. The incorporation of intelligent features adds value to homes and enhances the lives of those who inhabit them while contributing to better housing management.

There are a wide variety of automation and control systems, from basic mood lighting systems to full house automation that can be viewed and controlled from anywhere in the world. In this paper, we list the services and functions of domotic that can contribute for increased sustainability through better housing management.

Domestic automation is composed of a series of domotic systems (or services) that perform several interlinked functions. The main systems can be described as follows:

- Security and safety: intruder alarms, central locking of doors and windows, fire alarms, smoke and CO_2 detectors integrated with other systems such as lighting and locks;
- Comfort: environmental control, acclimatizing appliances control, appliance programmed timetable, lighting control, mobile phone alarm connection, medical alarms, and others;
- Management of energy systems: remote metering, energy read-out, effective heat and cool control, lightning control, electric appliances control, this systems encourage sustainability through improved use of energy;
- Information and Communications: open multi-media communications infrastructure for TV, telephone and computers, and house automation controlled from anywhere in the world;
- Entertainment systems and environments: online games, interactive digital TV solutions, home cinema, video-on-demand, and so on;
- Central control: central computer control of all systems;
- Disability systems: video cameras, CCTV and access control systems, alarms, and detectors for disabled, elderly, and sickness people or maternity.

First and foremost, it is important to address domotic as a means to manage home electronic appliances and to complement, not to substitute, passive solutions. As an example, we can point out that the incorporation of efficient heating and cooling systems, controlled by domotic, should not let us overlook the need to improve building insulation; instead, domotic should

function as a complement in those situations in which passive solutions are insufficient or difficult to achieve, as it is often the case in rehabilitation.

It's necessary to consider energy saving strategies that can be applied to existing buildings in rehabilitation. The intelligent technologies do not have to be confined to new building design.

In Portugal, housing represents around 13% of the country's energy consumption and it is breakdown as follows: 50% for kitchens and heated waters, 25% for cooling and heating, and 25% for lighting and appliances (Mourão 2005).

The use of solar passive strategies in existing housing frequently fails to satisfy the higrotermic and luminic requirements, mainly because design did not attend to the matter. This requires increasing comfort standards using active systems, but balancing them by limiting internal heat gains through the use of more efficient heating, cooling systems, and lighting systems.

In such contextss, better control systems for heating and cooling management are fundamental and can promote energy efficiency.

If a house can collect detailed information relating to environmental conditions outside and inside the house, this information can be used in domotic control decisions. For example, an efficient artificial lighting system has the ability to deactivate or dim itself in response to adequate natural lighting levels (Wigginton 2002).

There several domestic automation solutions that can be used for cutting energy consumption, including presence detection devices, solar control systems (intelligent control of blinds and other protective shades that can be lowered, raised and tilted according to the detected presence of the sun), and computer controlled ventilation by motorized opening of doors and windows. The specification of high and low temperature intervals and the increase of a few degrees in such intervals allow better energy management and it can be performed by a domotic system.

Systems that promote an efficient use of non-renewable energy sources, such as the split period power counter, the task ranking controller, and integrated systems for reduction and control of energetic consumption, are also domotic strategies in the sense that they aim at better energy management of the house. In addition, systems that use of renewable energies, such as solar water heaters, photovoltaics and wind turbines also can be integrated into domotic systems.

The information and communications systems are required in homes for two purposes: to improve the performance of the building through effective management of automation devices, and to help improving the lives of people within the building. For example, installing a cabling network at both the building and flat levels will allow residents to benefit from new media, such as cable television and broadband internet access with no need to use wireless technology or ICT infrastructures attached to the facades.

As an alternative course of action, the intelligent house, equipped with ICT and computer means that anticipate and respond to its resident's demands, can also serve the elder and people with reduced mobility, as well as other groups of habitants, in such a way as to secure their comfort and protect their safety, by allowing them to surpass obstacles and supporting the execution of their daily tasks.

For houses that require a level of control for disabled or elderly residents, the market offers nowadays numerous assistive technologies that can be designed to evolve as the resident requires more assistance around the home.

The smart house that provides assistive technologies to help living more independently can assist with:

- safety and security maintenance, such as effective alarm call and smoke, heat, water and gas detectors (Dewsburry 2005);
- automation or remote control of tasks that an individual is unable to perform, such as turning lights on and off, and opening or closing of doors, windows, and blinds;
- communication (external and internal);
- proximity or motion sensing;
- fall detection;
- assistance with food preparation and storage;
- unobtrusive ADL monitoring and assessment, that is, the use of control systems to provide passive and unobtrusive monitoring of residents and check that regular habits are kept;
- vital signs monitoring.

8 CONCLUSIONS

Information is playing an increasingly important role in our lives and, as a consequence, ICT is changing the ways in which we inhabit spaces. Recent intelligent technologies aim at maximizing the use of information with the dual goal of providing the house with increased information access and comfort through the use of automated control systems.

However, the crescent demand of domestic comfort is often incompatible with the environmental sustainability that we try to promote. The excessive use of heating and cooling systems, as well as, of other electrical appliances, together with the excessive use of water, are factors that improve the quality of the dwelling environment but push us away from environmental sustainability. Intelligent technologies can play an important role in energy saving strategies and can be introduced in existing buildings as part of their rehabilitation process.

In addition, the rehabilitation of Lisbon's existing housing stock must fulfill new space-use requirements demanded by the new, information age lifestyles. Such rehabilitation must also be guided by ecological, social, and economical sustainability. Ongoing research aims at identifying the strategies that permit to achieve an adequate balance between these conflicting goals.

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