Smart Home as a smart real estate : a state of the art review

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Abstract. In this paper, we review an emerging type of dwelling, indicated as Smart Home, with a focus on future user lifestyles, needs and preferences. Researchers envision a future information society stemming from the convergence of ubiquitous computing, ubiquitous communication and intelligent environments, especially residential environment. Smart Homes have noble aims; they are said to be able to support different ranges of activities such as tele-working, tele-shopping, tele-communicating, tele-educating, tele-caring, etc. in the home environment. Moving from the industrial society to the information society will transfer homes from only being a sleeping accommodation towards being the most important hub of human life. A change that will dramatically affect the design of social places, work places, residential places, cities and future real estate business and maintenance models.
In this paper, we investigate the major challenges of Smart Homes as a new dwelling concept. Surveys have shown that user acceptance of any changes in personal spaces is linked to user needs and preferences. In turn, user preferences are directly related to user lifestyles. Therefore, inspired by research in the field of user centered design and future lifestyles, we redefine the concept of housing to increase the acceptance and marketing of Smart Homes as future housing. By examining a number of examples, upcoming trends and developments in housing technologies and concepts are reviewed and analyzed. A multidimensional classification framework of a Smart Home suggested which allows a better understanding of the new elements and spaces of this future home environment. A new concept of a home environment is presented in which Virtual Space (VS) and Ambient Intelligent Space (AmI-S) are integrated with in the Physical Space (PS). Furthermore, possible changes for lifestyles as a result of activity changes enabled by new technological developments are identified. Linking the new home environment concepts comprised of VS, AmI-S and PS with the user's lifestyles provides a research framework for the investigation of Smart Homes. Through this framework we expect to answer questions on the feasibility and impact of new technologies on real estate. Which architectural conditions may promote acceptance of these new technologies by users. The presented research framework is not only relevant for academic researchers but also for real estate investors, because it highlights the risks that need to be managed when developing smart real estate.

Keywords: Smart Home, lifestyle, Virtual Space, Ambient Intelligent, Physical Space, housing design

1. Introduction

Rapid technological changes dramatically alter the demand for Smart Homes. Consequently, real estate decisions are going to be affected by new housing preferences and spatial patterns of Smart Homes. But what comprises a "Smart Home"? What are technological changes involved? And how will these technological changes affect real estate management and marketing? To answer these questions, this paper presents a research framework for a lifestyle-based approach in the domain of smart real estate. In the first section of this paper, we explore the technological and activity changes. We then, suggest expected changes in spatial conditions for the Smart Home, namely, space saving, flexibility and new spatial organization of smart living spaces, smart kitchen and smart workspace. Developing this research framework is helpful for further studies in real estate to analyze

interdependencies among spatial, lifestyles and technological parameters underlying future housing preferences. The aim of this effort is to provide an additional instrument for the estimation of real estate value for real estate managers in the future (Ahluwalia, 2007). It also provides opportunities to expand the boundaries of real estate research and to capitalize on the concepts and research techniques that exist in these fields. According to Roy et al. (2003), it is crucial to real estate programs not to be restricted to financial issues, but to have a broader focus with the lowering of disciplinary boundaries. He suggests that if every real property problem was seen as a finance problem, researchers would miss the opportunity to use tools and thoughts from other disciplines. Accordingly, this paper presents the following research framework as an approach to improve user satisfaction and acceptance in the domain of smart real estate.

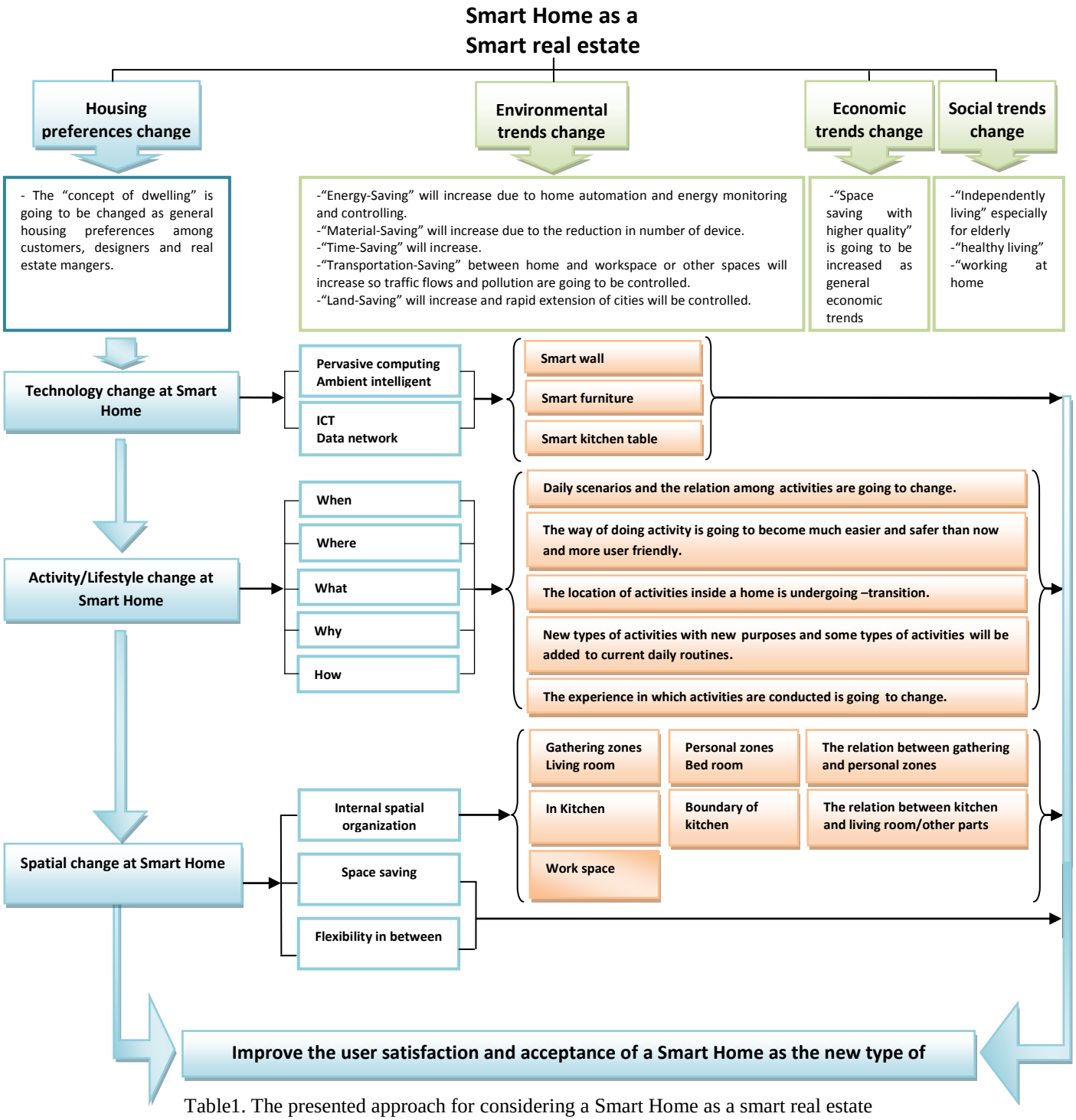


Table1. The presented approach for considering a Smart Home as a smart real estate

2. Changes in the Concept of Dwelling

> "Architecture is the thoughtful making of spaces. The continual renewal of architecture comes from changing concepts of space."
> Louis I. Kahn

The dwelling is meant primarily to support the activity "to live". When the way of living changes the conditions of the dwelling change accordingly. Compare, for example, the differences between the current high-equipped dwellings with the historical dwellings without any water faucets and toilets, central heating, electricity, improved cooking facilities, television and many other facilities. In this respect, "the home has been developed a lot over the last centuries" (Sandström, 2009).

Researchers envision a future information society stemming from the convergence of ubiquitous computing, ubiquitous communication and intelligent environments, especially residential environment. Junestrand (2004) observes that people are currently experiencing a major change in the way of living due to the transition from an industrial society to an information society. The key change is that people will spend more and more time in their homes, where they will also accomplish a wider range of activities, including professional work, Tele-educating, Tele-shopping, Tele –caring and etc. Therefore, the upcoming hypothesis is that the dwelling of the information society will have a different concept of space than the current dwelling. Meanwhile, the Smart Home concept represents an important step in this evolution, emanating from the all permeating information, communications and ambient intelligent technologies.

The most common concept of space in current dwellings is its categorization by functions, such as sleeping rooms, bathroom and living room(Junestrand, 2004) that can be traced to the "form follows function" design philosophy by American architect Louis Sullivan`s established more than a century ago. But due to the changes in people`s preferences and needs, the concept of space for houses in the near future might have to be reconsidered. In the future, people will execute an increasing amount of their everyday activities in and around the dwelling. The border between home-work and professional work will loosen up (Roy et al., 2003). A greater number of activities will also be supported by different kinds of Ambient Intelligence. Space in the information society is becoming more complex and can be understood as three spaces integrated into a new concept of home environment where Virtual Space (VS) and Ambient Intelligent Space (AmI-S) is combined with Physical Space (PS).

In the center of this new concept is the individual person. However, this individual is embedded into a family who lives in the house. In turn, the family has to be seen in the context of the general public. Three different kinds of activities are considered to as an integral part of this future spatial concept: a) Activities assisted by ambient intelligence. b) Activities concerning information. c) Daily routines. (Fig. 1)

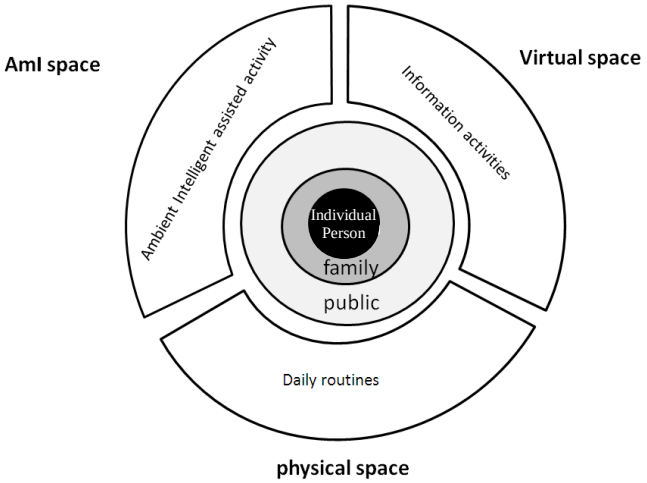


Fig.1.The new concept of space for Smart Home

- The Virtual Space (VS) consists of ICT appliances such as smart walls and smart furniture that are connected to an information network. It supports information-related activities, such as social networking, tele-shopping, tele-working and tele-learning.

- The Ambient Intelligent Space (AmI-S) refers to environments that are equipped with computers and sensors, in such a way that they can adapt to user activities through an automated form of awareness. This kind of space will improve physical-mental comfort and wellness. It will also assist daily activities such as cooking, sleeping, washing, eating and personal activities such as caretaking of elderly and child caretaking.

- The Physical Space (PS), on the other hand, is the traditional space where people actually are with their bodies.

3. Analysis of Smart Home as a new dwelling concept

3.1. Developing a research framework

The concept of Smart Home plays an important role in the planning of future housing models. An increasing number of research groups are working in this domain. An overview of some of them is provided in the appendix of this paper in Table 4. Each of these research centers is focusing on the concept of Smart Home from a distinctive perspective; Different names are used, such as Automatic home, Adaptive home, Com home and Smart Home. But what unifies all types of Smart Homes in a joint domain is their final goal. In 2007, the Smart Home Association in the Netherlands defined Smart Home technology as the "integration of technology and services through home environments for higher comfort and quality of living at home" (Bierhoff et al., 2007).

Improving the quality of life and comfort in the home environment is one of the oldest dreams of mankind and one of the most important reasons for developing technology. Although technology makes life more comfortable, it does not necessarily guarantee an improvement of the quality of life. According to the diagram of the quality of life introduced by Jacqueline Vischer (2007), there are three ranges of environmental comfort. Viewing comfort as a tripartite continuum can help to assess the overall quality of the living environment.

- Physical comfort encompasses aspects such as temperature, air, sound and lighting, or – from a technological perspective– HVAC and safety systems that have been researched extensively over the years in the domain of Home automation.

- Functional comfort responds to the user's needs and their preferences. Rather than a neutral state of unawareness, functional comfort is an active interaction with the environment. In such a way, that the environment supports people's tasks and activities. This consciousness requires thoughtful awareness and good design of both space and technology.

- Psychological comfort relates to human needs and lifestyles. This comfort is more related to the conditions of integration of technology with space for better compatibility with user`s everyday life (Aldrich, 2003); here, technology push is replaced by a user center approach.

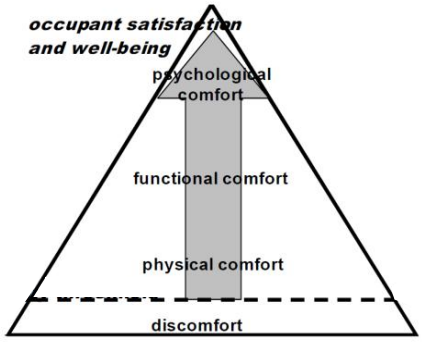


Fig.2.The three levels of comfort according to the occupant satisfaction and wellbeing (Vischer, 2007)

Accordingly, a framework for developing the spatial conditions of the Smart Homes that incorporates new technology and lifestyle is presented in this paper. It has three basic elements: ambient technologies, lifestyle (of a person) and house environment. New technologies can be applied in any space of a house; a lifestyle consists of activities and a house consists of spaces. Technological changes influence lifestyle and result in some activity changes. As a consequence, activity changes influence spatial conditions and result in changes of the space. The final result is a new kind of space which supports both psychological and functional comfort in addition to physical comfort.

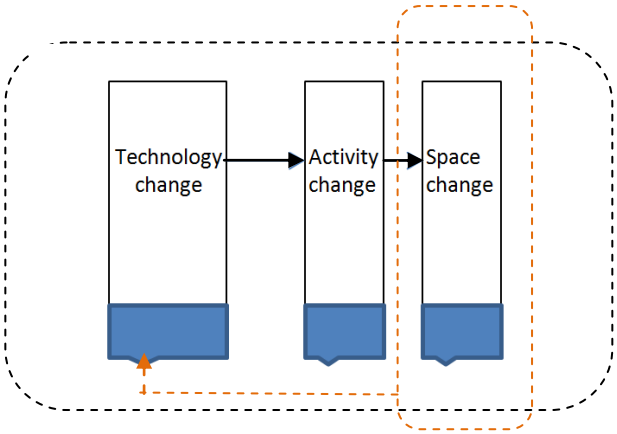


Fig.3.The research framework for the analyses of Smart Homes incorporated with future lifestyle as a result of technological changes

3.2. Technological changes

All the devices and spaces inside the Smart Home support people carrying out their everyday activities, tasks and rituals in an easy, natural and intelligent way. As these devices become smaller, more connected and more integrated into the home environment, the technology disappears into surroundings until only the user interface remains perceivable by users. These technological changes will affect the way of living at home and will influence the spatial needs and preferences of those living there.

3.3. Activity changes

As already mentioned, the introduction of Smart Home technology into future dwellings may result in changes in activities. In lifestyle studies of the future, the domains of work and life, education and home activities, daily routines and entertainment, public and private, are no longer strictly separated. At home, too, many activities are performed simultaneously; cooking while watching TV, monitoring the children sleeping in the bedroom while entertaining friends in the living room; working while doing other daily routines etc. So there is an interaction between a more complex set of activities in time and space. As reported by the 'Living Tomorrow' lab on a research initiative on future lifestyles (see Table4), houses which are completely networked, both inside and outside, enable permanent communication. Thus people can, for example, dictate the shopping list via the kitchen computer and in return they can be informed directly about the expected waste volume and the best disposal option. It is also possible to have a virtual team working while each employee is in his/her house. Intelligent ovens read the product information via barcodes on the food wrapping and program themselves. There are flat-screens everywhere, which show TV and Internet programs; each family member can have access to personal information and can work while doing other activities such as cooking.

According to the research of Ha et al (2006) on user behavior in home environments, each human activity can be categorized along five axis: When: Time, Where: Space, What: Object, Why: Reason and How: the way of doing that activity. The following table considers activity changes in a Smart

Home on the basis of this structure and represents the main changes of activities in relation to new technologies:

- When: Daily scenarios are going to be changed due to the programmable devices and intelligent devices. Also the duration of doing main activities will be reduced, while the time expenditure on some sub-activities such as relaxation and personal activities will be increased. Consequently, the relation among activities will change.
- Where: The location of activities inside the home is going to undergo a transition. For example, children gaming will come out the bedroom to the living room near the smart wall. Work related activities will also no longer be limited to any specific space such as the home office.
- What: Due to intelligent devices and furniture, the way of executing activities is going to become much easier and safer than now and will also be more user friendly.
- Why: Some new types of activities with new purposes are going to emerge and some types of activities will be added to the current daily routines, such as professional work, caretaking elderly, tele-communication and tele-learning.
- How: The experience in which activities are conducted is going to be different from now. (Alves Lino et al., 2010) In effect, the experience of many activities such as working at home, watching TV, kitchen related activities and wellness activities will differ.

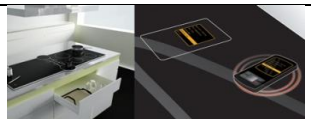
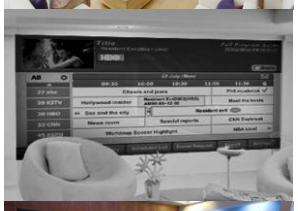
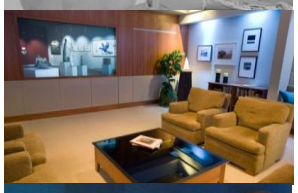
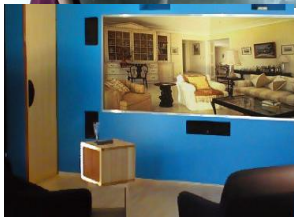
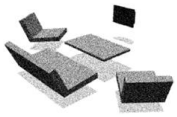
The table below illustrates all the technological changes and their effects on daily activities with a general view towards the latest attempts of different companies and research centers concerning different aspects of the Smart Home.

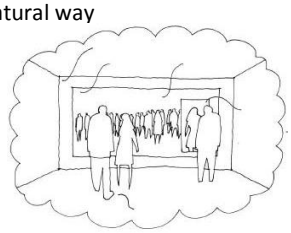
<table>
<tr><th colspan="2">Smart kitchen table</th><th>Technological change</th><th>Activity changes in the span of 4W & 1H</th></tr>
<tr><td>Multifunctional activities supported by a smart table with smart oven and touch screen LCD</td><td rowspan="3">  </td><td rowspan="3">It has:
• Oven :
– Flat
– Changeable in size
– Is not hot anymore after using
• Wireless power
• Touch screen LCD
• Internet connection
• Data network

It causes:
• Reducing the number of device

It supports:
A)
• Tele shopping and other internet usage
• Tele-communication
• Getting recipe
• Entertainment:
Watching TV, music, news
• Managing other home device

B)</td><td>Where:
a)The location of some activities will be closer to each other:
- Dining at the same furniture providing cooking facilities.
b) The location of some living activity will change and come in to the kitchen:
- Family gathering during cooking.
- Work activity during cooking.
c)The location of some kitchen related activity will change in the kitchen domain:
- Preparation activity during cooking.
d) Flexible zone/place for activities:
- The cooking activity is not limited to a single place, it is possible to cook on different parts of a smart table. Changeable, flexible and movable features provide several possibilities of food preparation whilst simultaneously carrying out other activities</td></tr>
<tr><td>Using Wireless power</td><td>When:
Increase the concurrency of activities:
The time of cooking and working or internet related activities are currently separated, but they can be done simultaneously in a smart kitchen</td></tr>
<tr><td>Connecting to Internet</td><td>Why:
The reason of being in the kitchen will be different. Nowadays, people are in the kitchen only for kitchen related activities, while, in future, the kitchen will serve as a central hub for gathering, entertainment and telecommunication etc.</td></tr>
</table>

Transferring data among devices by Data network	 	• Gathering family • Dining **C)** • Work related activity **D)** • Preparation food and other kitchen related activity	**How:** The activities become: more interactive, more programmable, more electronic **What:** Decrease of single-purpose devices: The integration of multiple functionalities into a single device makes fewer devices necessary: A smart table can uses for both warming and cooling food, for preparing activities, the execution of work activities etc.
Smart wall		**Technological change**	**Activity changes in the span of 4W & 1H**
Multifunction activities by smart wall (TV+ Computer) Virtual communication in more natural way Integration of Physical Space (PS) with Virtual Space (VS)	      	**It has:** • TV+ Computer • Touch screen LCD • Internet connection **It is:** • Integrated with wall • Multifunctional: it supports several activities • Connected to smart furniture and smart kitchen table • It is both interactive and representative. While TV is: – Representative – Used for watching movie, news, entertainment – Focus point of living room – People only sit in front of (around) it and far from it  And Computer is: – Interactive – People sit near it – Use for personal activities, – Used for internet related activities. – Located in special part of room, or portable: tablet, laptop 	**Where:** a) Social activities such as tele-communication will come inside the boundary of the house: Public activities such as having a formal meeting or a virtual party or participating in a virtual class are mixed with private activities such as family gatherings. b) Team-working can be facilitated virtually instead of requiring physical presence in a separate location. c) Work activities can be done in a common room instead of a separate home office. d) Playing activities by children can be done around it instead of their personal bedrooms. e) Relaxation can take place around it especially for elderly to use tele nursing, social networking and other services. **When:** a)The time of being with family and friends will increase: People can watch a movie jointly with their friends in a remote place. Parties can be hold virtually around it. b) Facilitated by telecommunication, the time working at home will increase due to telecommunication. **Why:** The reason of being around a smart wall inside a smart living room will be different from current living room use which often is focused around a TV. Physical Space (PS) is integrated with Virtual Space (VS). Social and private become closer and different activities such as work, entertainment etc. will happen around it.

Interactive activities, children's play, tele learning		**It supports:** • Multifunctional: it supports several activities • Personal activities • Internet related activities • Watching movies, news, gaming, music • Watching different program at the same time • Tele communication • Tele caretaking • managing home device • Work related activities • Presenting different scenery on the wall for changing the mood of the home. • Tele learning • Children's play	**How:** a)Virtual communication and activities can be done in more natural way  b)Watching TV is becoming more enjoyable c) The activities become more interactive.
Reduction in device			**What:** Reduction in the number of devices in the living space due to the integration of TV, radio, computers, and home appliance controllers.
Smart furniture / device		**Technological change**	**Activity changes in the span of 4W & 1H**
Accessing to Data network connecting to each other Managing home device by programmable Furniture		**It has:** • Sensor • Wireless power • Touch screen LCD • Internet connection • Data network **It is:** • Movable and flexible • Multipurpose • Equipped with a computer • Intelligent and aware of the user • Programmable • Changeable in shape • Interactive • Connected to a smart wall and a smart kitchen table  • Connected to social network/ hospital doctor and etc. **It supports:** • Virtual activities:	**Where:** a) Due to the flexibility and data network, the activities are not restricted to a specific space: Work activities are not restricted to home offices. So Workspace and life space can be integrated with each other. b) Due to the connection with smart wall, some entertainment activities such as children gaming will come out of the bedroom to gathering zones. **When:** a) The time for living and the time for work will be integrated. b) More time for work related activities will be spent at home. c) More time for educating will be spent at home. **Why:** Furniture supports multiple activities for example the aim of sitting in an armchair is more than relaxing, since it supports managing other devices, computer related activities and work activities. **How:** a) Doing activities are becoming more comfortable because the environment and furniture adapt itself with users` situation: While studying, the lighting will become suitable; the armchair will adapt itself with your body. b) Doing activities are becoming safer due to the use of sensors: For elderly, if users fall down from the furniture, it

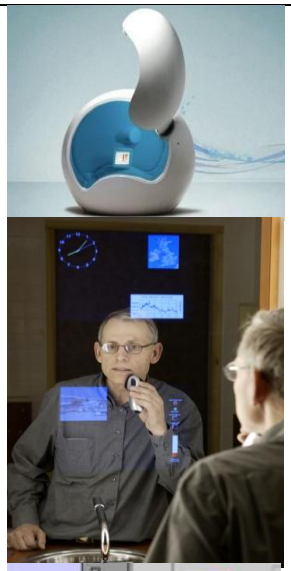
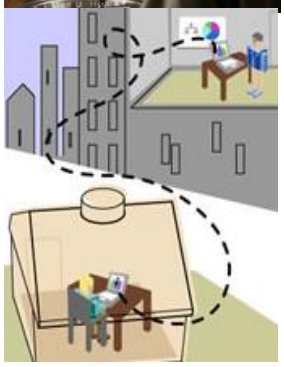
Doing interactive activities by smart furniture, Smart bed and smart mirror		– Tele- communication – Tele- shopping – Tele-working – Tele- team working • Physical /agronomic comfort for different kinds of activities/people: • by reading signals from the user's body, the furniture automatically adjusts to create the most comfortable and physically beneficial shape for the user's posture. (Sang Hyun Park et al., 2003) 	will detect the incident and send an alarm to the nursing center. c) The activities become more interactive by smart furniture. For example: Sleeping in a smart bed becomes personalized. The user can interact through an interface integrated into the bed to adapt the environmental color, temperature, music. While washing his or her face, the smart mirror can display the news or other helpful information. d) The activities can be done in healthier and safer way. For example, the users' body can be scanned in the wellness zone and data sent to be monitored by a physician. If something unusual happens to the user, the furniture can detect the incident and sent out an alarm.
connecting to social network, having virtual team working		• Entertainment • Managing other devices • Adapting HVAC and lighting conditions to users` activity • Controlling energy • Safety and independent living for elderly and disabled people	**What:** a) Work devices integrated with other living devices and furniture b) Furniture is equipped with sensors, speech recognition, face recognition, activity recognition. c) Reduction in the amount of devices in the living space, due to the integration of computers and furniture. d) Furniture can be connected to social networks, so inside of a house is connected to the outside.

Table.2. Analysis of technology and activity change in the Smart Home

4. Results

According to the analyses (Table2), when technological developments come through the Smart Home and many changes occur to the conditions underlying of the conduct of activities, a new lifestyle will be formed. In order to facilitate such a different lifestyle inside Smart Homes, some spatial characteristics are needed to support users` real comfort, to increase users` satisfaction and also to increase users` acceptance. Furthermore, while space change is an origin domain in the field of Smart Home design, there are several questions that seem important issues in future real estate managements and marketing. Questions such as:

- How will floor plan layouts of the dwellings be affected?
- What should a general floor plan layout look like in a home of the future, when integrating different new technological facilities with different spatial requirements?
- How should the different design patterns be formulated in order to generalize the experiences of new technologies, developed for the Smart Home?
- How should the home spaces be designed to support the activities which are supposed to be supported by new technology?
- What is the organization of time and space for everyday activities in a future home environment?

The resulting spatial changes are categorized in three categories: a) Changes of internal spatial organization in three main zones which constitute smart living spaces (family gathering zone and personal zone), smart kitchen, smart workplace and the relation among them, b) Flexibility-in between, c) Space saving.

4.1. Internal spatial organization changes

With respect to the domain of spatial organization changes, the focus of this paper is limited to three main categories of the Smart Home which are summarized as kitchen space, living spaces and work space also the relation among them. These areas correspond with the three main areas that are mostly influenced by new technologies in a Smart Home.

4.1.1. Smart kitchen

While contemporary kitchen still is a distinct area in most homes, in the house of future the kitchen is recognized as an important place for family gathering as well as for cooking. According to Ahluwalia (2007), a current trend is to have a kitchen as the hub of the home more than ever before. Families want the kitchen island to be large enough to serve as a multi- purpose location: As a place to do homework, crafts, and to pay bills, as well as to enjoy a cup of coffee. It is predictable that more and more people will tend to have a kitchen integrated with the living space to support their multitasking because of the increased time spent at home in the future. Understanding the trend, conceptual kitchens will be integrated with living spaces especially when smart technologies such as wireless power and smart devices make them feasible. In terms of design, there are some ideas that try to interpret the kitchen as the hub of the home. The "Hettich Kitchen Concept 2015" with a smart island and a smart wall presents a kitchen integrated with other parts of the home environment rather than claiming to be the centre of attention (Stackelbeck, 2009). The smart kitchen of Philips also presents an “Interactive Kitchen Table” as the focal point of any domicile. Friends and family would gather around this table and relax, chat and perhaps even help out with the cooking. Here, no preset cooking zone exists. Cooking takes place in different parts of the ‘Dynamic Table Top Interface’. Kettle or pans can be passed to others at the table so they can finish preparation; the wine cooler can be shifted to make room in order to chop food. These devices continue to cook or cool and energy flows follow them as they move around the surface, and so does the display interface on the table top surface. This table is both a dinner table and a stove. It not only helps to save space, but it also makes the kitchen environment more social and convenient (Philips designers, 2008). Several other research centers such as Kitchen of the Future (GE/USA), U-Style (Samsung/Korea), Barrier Free Kitchen (ITOKI/Japan), Cultivation Kitchen (INAX/Japan) are developing smart kitchens to improve the integration of kitchen related activities with life (see part A in Table3). In general, these concepts try to introduce a kitchen free from a room with no physical boundaries that can support multitasking activities such as entertainment, social communication, virtual activities, job_ related activities and family gatherings etc.

Using smart devices, information networks, wireless power, flexible work spaces and other technologies presented in the Table 1 are very helpful to achieve this goal but new architectural options are also essential to be investigated for a tighter integration of the Smart Kitchen in to people`s lifestyles.

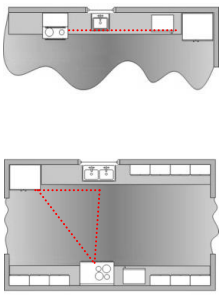
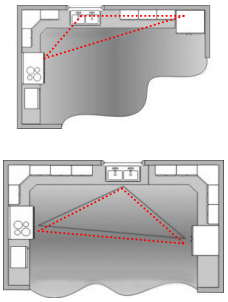
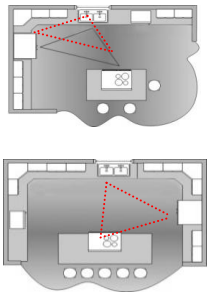
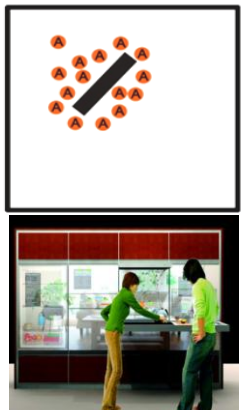
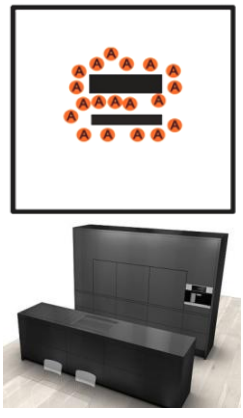
4.1.2. Smart living spaces

Smart living rooms which are most affected by Smart Walls will support different activities in future dwellings. The space should allow many activities at the same time or at different times. Both interactive and passive activities are supported by the Smart Walls, including watching TV, children gaming, Tele educating, Tele working, Tele communicating and surfing on internet. These new interactive aspects influence the location of the Smart Walls, the arrangement of the furniture around it and the entire space. Such new layouts will be fundamentally different from the current living room layouts predominantly designed for passive TV consumption (see part B in Table3).

Personal zones and wellness zones and their relation with public parts of a house are another important issue in studies of the spatial organization of future Smart Homes. In this regard, Susanka (2004) argued that instead of conceiving a house as a series of rooms dedicated to single functions, it is more useful to think of it as a collection of multifunctional places in which the various daily activities of household can occur. The results of the “Home of the Future” survey suggested that

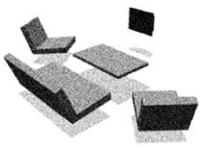
people also need a bedroom as a private zone beyond the purpose of sleeping (Ahluwalia, 2007). Thus, when activities shift from the bedroom and take place in other spaces, bedrooms seem not to be required anymore in their current style and sleeping zones as private zones will likely emerge instead. In his research "The Future Evolution House" Horx (2009) claimed that certain rooms will likely disappear in future houses and will be replaced by multifunctional spaces. He also stated that spaces dedicated to wellness will be among the most important parts of future houses (see part C-1 in Table3). Similarly, a study published by the "Living Tomorrow" lab (see Table4) claims that bedrooms will be replaced by cozy islands with integrated multimedia (see part C-2 in Table3). On the other hand, the relationship change between private and public zones is one of the crucial issues to be addressed due to transformations in social patterns in a Smart Home (Junestrand,2004) (see part C-3 in Table3).

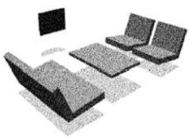
All these statements reveal that the spatial organization of the Smart Home needs some redefinitions to suit future lifestyles resulting from new technological developments.

Part A) Kitchen				
Current kitchen				
Space change ideas for Smart kitchen				
Smart Kitchen	A-1) Integrated with other living space	A-2)Barrier free kitchen	A-3)Comprised kitchen in a smart wall and table	A-4)Multipurpose interactive smart table
	-Sedan K Italian Kitchen concept It is an integrated kitchen to offer a new concept of space. Low, inviting chairs with jutting armrests surround the kitchen. A huge, abstract screen known as the "Techno Wall" conceals the appliance out of sight for when users are entertaining.	-Kitchen of the Future(GE/USA) The entire suite offers a full width display combined with touch sensors across the entire surface	-" Hettich Kitchen Concept 2015" The places dedicated to work, to relax and to live to cook, once separated, became linked on the smart table, changed from multiple to single.	-Philips Green Cuisine /Interactive Kitchen Table The table is an important place for family gathering to have multitasking.
				

Part B) Living room

Current living room

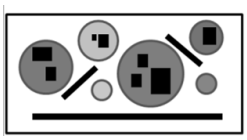


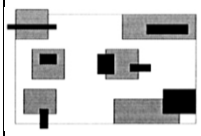


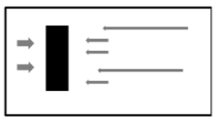
Space change ideas for Smart living room

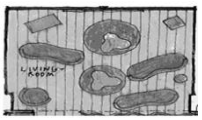
Smart living room

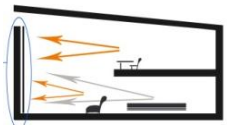
B-1) A main smart wall and different activity place around it. It supports multitasking.	B-2) Flexible smart wall (in shape and location)	B-3) A smart wall in the middle of a space	B-4) A smart wall in one side of the room and flexible smart furniture arranged around it.	B-5) A double height smart wall and different activity places in around it.
-Jigozen House, by Makoto Tanijiri 2009 - Kamiosuga House, by Makoto Tanijiri, 2009 "Rooms within a room" provide a series of platforms offering many levels of privacy for activities. Because of the way spaces are used in the apartment, people can have the freedom to open up or close off certain areas to suit their needs. These space renovations create a new concept of living space.	-Com HOME by Junestrand Can be used in different situations for different activities.	-Warehouse: Shinichi Ogawa Place work space and living space beside smart wall which is located in the middle of space.	-Room ware by MIT Com HOME by Junestrand To support different kinds of activity around smart wall	-Proto Home by Los Angeles architectural firm. While the smart wall is central, other zones provide continuous feeling of open space. Activities aredone around the smart wall while they have privacy.





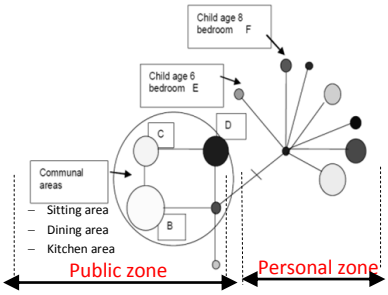






Part C) Personal zones

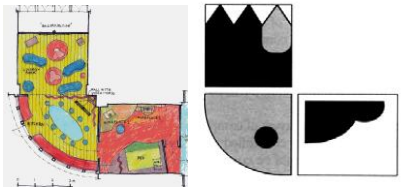
Current Personal zones



Space change ideas for Smart Personal zones

Smart personal zone

C-1) Multifunctional spaces instead of certain rooms / decrease the number of separate rooms	C-2) Smart bed as sleeping zone / Cozy island with integrated multimedia	C-3) Different relationship pattern between private and public zone to support social activities inside the home
-" future evolution house" by Horx	-"Smart bed" in living tomorrow	-com HOME by Junestrand



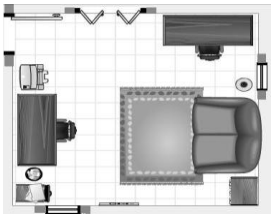
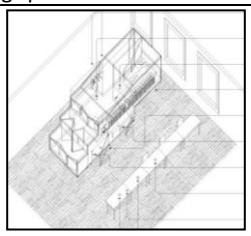
Part D) Home office			
Current working space			
Space change ideas for Smart working space			
Smart working space	D-1) Boundary less physical spaces	D-2) Virtual workspaces	D-3) Integration with other living space
	-Danish home office furniture Any corner in house has the potentiality for working activities thanks to ICT and AmI. So work activities are not restricted in specific physical space.	-com HOME by Junestrand Wireless connection, data network, smart wall, smart table are required for future spaces to support work activities.	-The Briefcase Ware House by Jimenez Lai It is a warehouse with no partition. This project is a house within a house. Furthermore, it blurs the boundary between the definition of working space and living space.
			

Table3. Overview of ideas for spatial changes in the Smart Home

4.1.3. Smart workspace

Throughout the past century, work space and home became increasingly distinct both mentally and physically. Work and private life were considered as separate spheres. But according to Leonard (2006), this trend will be reversed again by an increasing integration of the two domains. Increasingly more people are beginning to work from home either part-time or full-time. Changes to the nature of work including technological advancement, the introduction of flexible working hours and tele-working increasingly interweave work activities with home life. On the other hand, as Kennedy (2009) remarked "the more time spent working at home, the greater integration and blurring of home and work boundaries will happen". That is to say, that work-related activities on the one hand and private activities on the other will be integrated in future rather than be balanced as presently done.

In the paper presented here, it is shown how work-life integration in the Smart Home is affecting the boundaries between work space and other living space. The most important advantage is that people do not need a specific space to make it work. Any corner in house may be suitable as a home office thanks to ICT and AmI technologies. In such a scenario, some granted boundaries between spaces may dissolve and more negotiation around tasks may take place. A number of shifting boundaries including those between work and private spaces in the house will be introduced. Due to these changes, an architecturally distinct area is no longer required and the separation of work space and living space is increasingly broken down and rearranged by "blurring boundaries" (Leonard, 2006). The former physical separation of work in public spaces and non-work in the private spaces of the home does no longer apply in the same way. Hence, smart technology has brought profound changes to the ways people work at home, with boundary less physical spaces, more virtual workspaces, and the potential for constant wireless connection to one's work. The workplace is no longer necessarily a discrete physical location. While this level of integration is achievable by technological developments, the complexity of managing both work and home activities needs more researches to manage all "crossover" work activities at home (Sellen et al., 2004). Hence, any successful model of work-home integration needs research on the spatial aspects of workspaces in the Smart Homes.

To address these challenges, some architectural ideas are reported in the following table based on studies of available smart domestic environments.

4.2. Flexibility in-between

The main advantage of ambient intelligent technology in the Smart Home is improving the level of flexibility in the ways of doing activities. Each home allows users to experience open and livable flow in the multifunctional smart zones. Rather than living in static and restricted rooms, the home promotes "flexibility in-between" for spaces. In other words, a Smart Home improves the possibility of spaces by technology and multitasking in each space while the physical elements of the space itself can be completely or partially fixed. The final result can be an open space with multifunctional zones equipped with some flexible smart furniture and devices which are networked. The available example of flexible a prototypical Smart Home is the Proto Home (see Table4) which has an open space with a main core and other applicant around it.

4.3. Space saving:

The possible contributions of smart home concepts and developments to space saving are:

- Reducing the need of distinct physical spaces for special activities. Activities are not restricted in space thanks to pervasive computing and data network,
- Reducing the need of distinct physical spaces for home office because of the integration between work activities with life,
- Reducing the number of devices in a house,
- Mixing several zones with each other and blurring the boundaries by multitasking,
- Use of virtual space instead of physical space by several tele-activities,
- Use of flexible and multifunctional devices and furniture,
- Improvement of the flexibility of spaces,

Such a "build better, not bigger" design approach is one the great benefits of the Smart Home notion that requires more research in future real estate studies.

5. Conclusion

As shown in this paper, residential dwellings will likely become the most important hub of human life due to technological developments. Current homes however seem to be poorly prepared for this future. "The housing industry, for the most part, is resistant to change, wary of new technology, inefficient, and unresponsive to the future needs. Most people live in places that are low-tech, inflexible, disruptive to upgrade, and ill-designed" (MIT whitepaper, 2005). Smart Home is a potentially interesting and valuable concept to consider physical space, technological interfaces, and human activities simultaneously in dwellings.

At present, most of the Smart Home research is focused on improving the potential of devices, regardless of their use to real-world family lifestyles. As an example, a Smart Wall is designed to support different activities in a future living room (Table2). However, from a lifestyle perspective, some day-to-day scenarios will likely cause sociological problems in its use and will contribute to a decrease of acceptance of such technologies:

- Father wants to have a telecommunication session, while the children want to enjoy entertainment and mother would like to watch a movie at the same time.
- Both parents want to work with the smart wall at the same time.
- The children need the smart wall for tele-learning at home, while the mother requests its tele-working capabilities.

The above scenarios show that although the main purpose of the Smart Home concept is to improve the quality of living and comfort via AmI technology, the integration of the technology with space and

corresponded spatial conditions are vital for its accomplishment. Therefore, the main question is how the Smart Homes can practically provide spaces that respond to the complexities of life with new technologies.

As a potential answer to these challenges, the paper presents a state-of-the art review considering the necessary transformations of space in Smart Homes by taking potential lifestyle changes as well as spatial facets into consideration. This approach is useful to the housing industry of the future in order to promote home environments which accommodate new complex activities and ever-changing technologies. Furthermore, the exploration of patterns of technologically mediated activity and interaction in domestic environments presented in this paper has allowed us to consider the potential of this approach as a means of presenting empirical work to developers of technology in the domain of real estate. We consider technology to be one of the most effective aspects in the marketing of future houses.

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7. Appendix

1	Living tomorrow lab, Brussels, Belgium	http://www.livingtomorrow.com/#/en
2	The Smartest Home, Eindhoven, The Netherland	http://www.smart-homes.nl/
3	Australia's first Smart Home, Sydney, Australia	http://www.ausgrid.com.au/smarthome
4	Internet Home, Cisco, United State	http://home.cisco.com/en-us/wireless/ http://newsroom.cisco.com/dlls/fspnisapi3934.html
5	Adaptive House, Colorado, United States	http://www.cs.colorado.edu/~mozer/index.php?dir=/Research/Projects/Adaptive%20house/
6	Com HOME, Madrid, Spain	http://www.leal-junestrand-arquitectos.com/?page_id=212
7	Easy Living, Microsoft, Washington, United States	http://www.cs.washington.edu/mssi/tic/intros/Shafer/index.htm
8	House of the Future or House-n, MIT, United States	http://architecture.mit.edu/house_n/
9	Home of the Near Future& Home Lab, Philips, Eindhoven, The Netherlands	http://www.newscenter.philips.com/main/design/news/publications/bispublishers_book5.wpd
10	Smart Home, Siemens, Munich, Germany	http://www.siemens.com/innovation/en/publikationen/publications_pof/pof_fall_2008/gebaeude/vernetzung.htm
11	Science and Technology Policy Research, Sussex, England	http://www.chessclubs.webspace.virginmedia.com/smarthomecontrols/index.htm
12	Intel Architecture Labs, Santa Clara, United State	http://techresearch.intel.com/ProjectDetails.aspx?Id=84
13	Panasonic Smart Home V.2, Tokyo, Japan	http://wn.com/panasonic_prototype_eco-house_in_tokyo,_japan
14	Aware Home, Georgia Tech, Atlanta, United State,	http://awarehome.imtc.gatech.edu/
15	TRIL/technology research for independent living, Ireland	http://www.trilcentre.org/technology-design.html
16	Proto Homes, Los Angeles, United State	http://www.protohomes.com/

Table4. An overview of the research groups in the domain of Smart Home