OLD AND AT HOME IN AN INTELLIGENT ENVIRONMENT

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ABSTRACT

Due to the rapid aging of the Dutch population and aging-in-place policies, an increasing demand for suitable dwellings is to be expected. A significant contribution can be provided by domotics defined as: the advanced technological equipments and services in the domestic environment to sustain and to enhance the quality of aging in place as well as empowerment of the senior citizen (in daily life).
This paper, based on literature review and qualitative and quantitative studies, (i) seeks to inform the development of domotics technology in the living environment of the older adults; (ii) provides an overview of the multiplicity of needs and attitudes of the older citizens regarding smart technology in the domestic environment; and (iii) develops recommendations to incorporate domotics in the architectural structure of the dwelling.

Study to senior citizens' needs and attitudes toward domotics is based on triangulation of cohort-group discussions, enabling techniques and in-depth interviews followed by a postal questionnaire survey. Hence, based on the identified needs, two houses, occupied by the elderly, have been upgraded by domotics.

The findings indicate that needs, perceptions, environmental and personal attributes of the senior determine the attitudes towards automation. This attitude can best be described as 'critical/positive'. Too much automation is undesirable. Ethical considerations are particularly related to professional stakeholders, especially caregivers, whereas seniors are mainly interested in the functionality of domotics. In the elderly housing, the stage of stand-alone devices is outdated. It should be focused on the networked home and the integration of domotics in the house. Innovation by addition in a traditional construction environment often results in sub-optimal solutions. The results confirm that the integration of intelligent technology in a house needs to be a synthesis of the user's needs, technology, the living environment and healthcare.

Keywords: aging in place, domotics, attitude, residential needs, senior citizens, case study

1. INTRODUCTION

Not only in The Netherlands the issue of (double) aging of the population is raised, this is also the case in most EU-countries. The elderly policy and consequently the health care system are liable to large changes. A shortage of formal care threatens and at the same time an appeal will increasingly be made to self management and informal care. Extramuralisation results in longer independently living of the elderly while they receive the necessary care at home. This has an effect on the way of thinking about 'living and residing'.

However aging well and improving the quality of life for older citizens is becoming a progressively essential mission for the most (European) countries. The EU is undertaking the aging related problems as part of the general strategy of the mutually reinforcing policies launched at the Lisbon European Council (2000).

Viewed from an economic perspective it seems that senior individuals who remain living in their homes save society up to €16,000 per person per year (SCP 2004). In 2030 37% of the Dutch population will be 55 years or older; this means a small six million people, so we talk about a small hundred billion euro per year.

Aging in place is a philosophy as much as a concept that promotes independency and habitability of all types of houses (Lawlor and Thomas 2008) which refers to the ability to remain in one's home or neighbourhood as long as possible (Nasar and Evans-Cowley 2007) regardless of the age of the occupant or his level of abilities. It is a complex topic since it is imbedded in the broader context of the social, physical and organizational

environment. This means that in order to optimize a senior's home, not only healthcare must be sustained, but also the suitability and accessibility of care and services in the near surroundings. This concept supports such not only fundamental attachments of the older adult but also the level of wellbeing, convenience, security and care. Aspects of universal and barrier free design, adaptability, visitablity, and accessibility (Lawlor and Thomas 2008) are incorporated in the aging in place philosophy.

One of the most challenging paradigms regarding Quality of Life is "active aging"; a term gradually being used more often in current policy discourses on the international level, put forward by the World Health Organization. According to the WHO (2002), active aging is "the process of optimizing opportunities for health, participation and security in order to enhance the quality of life as people age".

Acceptance of the decline in capacity of a person is referred to as an assimilative behavioural response; the acceptance results in the loss of their aspired lifestyle. The senior is often forced to adjust himself to his (physical) limitations and often unsatisfactory housing situation and Quality of Housing (Mohammadi 2010).

Nowadays the dwelling gets more and more functions; it is not only a place to stay but also functions like working and recreating get in the picture/ come on the screen. It will also be the place where in certain a part of life people can receive care. To realize these, particularly the latter one, the home (and living environment) should be amended to provide the care and services. This is no simple matter. It includes not only new designs for the new buildings for the elderly housing, but especially the adaptation of existing housing stock.

Making the houses suitable for aging in place and improvement of the quality of housing, by for instance optimal adjustment and by implementation of domotics, has a direct influence on the wellbeing and the quality of life of the seniors. Aging in place is a complicated subject since it is embedded in a broader context of the social, physical and organizational environment.

Domotics can be an adequate medium to enhance quality of housing and empower the senior for a self-reliable life, as long as a balance is struck between the daily activities of seniors and the share of technology in it. However, seniors want to decide independently whether or not they will apply current technology; this can conflict with the rigid domotics applications. Technology must respond to the needs and feelings the seniors' about advanced technological appliances at that particular time.

The mentality and lifestyle of the contemporary senior differs substantially compared to a senior from previous generations (e.g. Dychtwald and Flower 1990, Freedman 2002). Current seniors (55 years old and over) are emancipated, active, self-conscious, follow courses, do volunteer work, and travel. They want to be involved in the society for as long as possible and want to organize their own lives independently. The former deficit model has been abandoned and replaced with active participation (Verté and Witte 2006). Both labour participation, participation in the social life or volunteer work enable seniors to maintain and expand their social network.

In the contemporary gerontology, the competence model is used (Ven 2007). This model emphasizes the competences and skills that the senior (still) has without being pessimistic or unrealistically optimistic.

Hence, in the case of senior citizens there is talk of individualization trend refers to the need for an individual to unfurl oneself and to make life decisions independently. A shift from materialistic gratification to self actualization (Idenburg 2005) is present within this trend which can influence the attitude of this target group regarding technology at home.

For this reasons in this study we seek to gain insight into the residential needs of seniors in order to develop domotic homes in which senior individuals can and would like to live in. User demand has been taken for granted in this research, nevertheless by further analysis of the demand is examined on which actual need(s) this demand is based. Therefore the relation between the inhabitant's needs, preferences, and underlying motives are investigated by the user needs analysis and research into the attitude.

Based on the identified attributes of these empirical studies two houses, inhabited by the senior persons, are adapted in a case study. This case study focuses on the infrastructural problem of implementation of domotics in the existing homes.

2. DEVELOPMENT OF DOMOTICS AND SAMRT CARE TECHNOLOGY IN THE LIVING ENVIRONMENT

Domotics is not new, but for a long time the emphasis was on the technology. Experience has shown that people are not waiting for an overdose of technological ingenuity.

Domotics can be an adequate medium to empower the senior for a self-reliable life, as long as a balance is found between the daily activities of seniors and the share of technology in it. Technology increasingly plays a role in all aspects of the health care. Based on literature (Singh 2005) Smart care technology in this paper is classified in six main categories assistive (such as wheelchair, hearing aid), safety (e.g. alarms), labor-saving (e.g. ceiling suspended lift), environmental (e.g. tap lights that change color based on temperature), information technologies (different hard and soft wares for staff training, interactive tools such as tele-conferences, administration, decision support systems), and tele-care.

Tele care is about care and service on "virtual" line which means the care provider is not physical present and contact takes place with(out) video connection. It implies that the inhabitant's functions can be measured and monitored and that he can be counselled and diagnosed on distance.

In the Netherlands, an ongoing development concerning shifting from intramural to extramural housing for the older citizens is present. Research has been done on several subfields; to name a few: researches compliant with adaptability of houses, alternative modes of housing such as small scale communities, quality requirement for the housing for the older adults to have a quality mark; researches into the user needs by divers research institutes and universities (e.g. TU/e, TNO, Netherlands Housing Research, Kittz, NIZW) and by various housing corporation and companies and organization.

Similar developments have taken place in other countries. Below we discuss the situation in Germany and some Scandinavian countries, as an example. Generally, these researches aim at the aspect of 'safety', for example towards alarm and warning systems.

The situation in Germany shows many similarities when compared to the situation in the Netherlands; small scale communal dwellings ("Hausgemeinschaften") developed due to the dissatisfaction of nurses with the large scale residential care homes (Singelenberg 2002). According to ICT & Aging European Study on Users, Markets and Technologies, social alarms have been available in Germany for more than 25 years, and they are now used throughout the country and mainstream housing organizations have now started to provide social alarm services. A range of stand-alone home automation products are available on the German market (i.e. electric shutters, home security systems, intelligent lighting systems, energy management systems). However, up to now, these solutions specifically geared towards the needs of older people have only been implemented in experimental settings.

According to Kristensen (2007) approximately 20% of the entire Danish population is more than sixty years old and almost all elderly people live in ordinary housing: single family houses, social housing, rented private-sector housing, etc. Only a very small proportion (8%) of the elderly live in housing that in some way or another is specially designed to cater to their needs. He argues that one important explanation of why most elderly people in Denmark prefer to remain in the home they have always had is that they can receive home help and be nursed in their own homes if they become frail. It is the local authority that grants help on the basis of the needs and requirements of each individual elderly person. In other words the level of accommodations for seniors in Denmark is very high; keywords of the Danish model are: small scale character and hominess. Care and wellbeing are merged; the accent is not on healthcare, but on social services. Seniors can remain living independently or choose to live in small-scaled clusters of houses with district amenities around which are present in each municipality. The principle of small scale home has been broadly carried out and has been realized by the separation into districts (Banks 2004).

Research is taking place in other Scandinavian countries into, among other things, the meaning of domotics to rehabilitation and preventive healthcare. They strive to improve mental and social skills.

In Norway and Finland, domotics and ICT are being implemented broadly, also due to the strong individualism and long distances. For elderly people in Finland, private and municipal nursing homes exist, sheltered houses and old people's homes, or they live at home; which housing type depends on the person's financial situation and physical condition (Aalto and Saari 2009). In general, it is claimed that the majority of sheltered housing for older people in Finland is smart housing to some degree, and incorporates numerous smart

systems such as barrier free design, automatic fire alarm systems, alarm phone with wrist bands, automatic light switches and door opening systems, as well as sometimes the occasional additional sensor.

In Sweden research has also been done into the development and implementation of domotics systems. Due to the wide availability of broadband in Sweden, several new services have developed such as: energy measurements in apartments and the development of a national IT-infrastructure for healthcare. In the year 2000, a programme was initialized within the Swedish Handicap Institute called “IT in Practice” which aimed to develop and apply IT for handicapped individuals (Spindler 2001). The final evaluation of a nationwide infrastructure in Sweden called Sjunet, which is part of Carelink (national cooperation for the development of IT in healthcare), showed that a good infrastructure both within the home and nationwide open up possibilities for the support of independent living.

Essen (2006) concluded that many innovative projects in Sweden failed because of the fragmented approach on the component level, by lack of finance, and by lack of cooperation between different actors who were involved in independent living. It is recommended to use a multidisciplinary approach, where the target group itself is involved in the developments from its initial phase.

The Netherlands counted about 40 domotics pilots in 2001, with a total of about 1500 dwellings that contain different combinations of applications (Nouwens and Corpeleijn 2003). According to ICT & Ageing, European Study on Users, Markets and Technologies it is estimated that this number increased by 22,500 homes by the end of 2008, which means that about 3% of the older adults lives in domotic homes in the Netherlands.

A number of evaluations and studies into the needs have been done by different organizations such as, TNO, NIWZ, and KITTZ; these were mostly focused on the usability of devices (e.g. remote controls) and the utility of certain functions such as alarms. It was concluded that seniors do want to use domotics, but several practical problems tied to the user friendliness of devices and the lack of information and post-purchase customer service need to be resolved.

So we distinguish three phases in the evolution of automation within the home: (i) only technology is central, what is technologically possible? (ii) influence of technology on home design; and (iii) “home” is central, i.e. a place in which the occupant and technology come together.. It can be concluded that the attention which at the beginning stage was mainly aimed at automation itself gradually moved in the direction of the house, living and the occupant. This shows the importance of the integration of the technology in home which is also the perspective of this paper.

However, there is still a deficit of knowledge when it comes to the residential needs and the attitudes of the dweller (ECTP 2007, Dellaert and Stremersch 2005) especially when it comes to the design of suitable houses and to develop products for older adults.

In order to develop domotic homes in which senior individuals can live in independently for as long as possible, it is important to gain insight into their residential needs. These are decisive for the determination of the preferences regarding domotics. In this investigation the relation between the inhabitant’s needs, preferences, and decision making processes; and the underlying motives, norms, and values is investigated by using the user needs analysis and research into the attitude.

Nevertheless, the current housing stock for seniors is problematic: they are quantitatively and qualitatively insufficient and inadequately adaptable. There is a shortage of suitable houses for senior citizens (ECTP 2007, Lichtenberg 2005). There is a need to develop new concepts and technologies to upgrade (existing) houses.

It is for this reason that this study focuses on adapting and retrofitting of the existing stock.

3. RESEARCH INTO ATTITUDE OF THE SENIOR CITIZENS REGARDING SMART TECHNOLOGY

The theory of Reasoned Action (Fishbein and Ajzen 1975) from the social perspective and strategy of aging-in-place representing the domain of the building environment are the basis of the theoretical framework for this study.

The desired domotics functions and the available technology are brought together in this investigation, i.e. the needs and attitudes from the demand-side are related to the available choices on the supply-side and subsequently, translated into the characteristics of the domotic home.

The identification of useful functions and domotics appliances are derived from a careful and iterative process of analysis, synthesis of past works (Mohammadi and Erkelens 2008), and two empirical studies into attitude of the older people in the Netherlands.

Most studies into the effects of attitudes on behaviour are based on the Theory of Reasoned Action (TRA) (Fishbein and Ajzen 1975), which represents a comprehensive theory of the interrelationship among attitudes, intentions, and behavior, and the Technology Acceptance Model (TAM) (Davis 1989) which focuses on explaining attitudes impacting on decisions to use specific technologies.

On the other hand, it is important to realize that these models focus on assessing the attitude towards technologies that are currently being used by consumers. Potential users view a new technology and accept it differently than users (Yu et al. 2005). In fact, users have already accepted the new product and will only recognize imperfections. Potential users are not familiar with the product; they have to familiarize themselves with the product and form an opinion about the product.

However, domotics is not intensively implemented in the market and the majority of the senior citizens do not have any kind of experience with these types of products.

Predicting the influence of possible variables of a product that does not yet exist or is still in development can be problematic (Deursen et al. 2006). To form a clear image of any missing factors or the causality of factors, a mix method is used and the study includes both qualitative and quantitative strategies. Qualitative research methods are explorative and diagnostic and give an answer to “what” and “why” questions and gives a picture of the motivation and needs that lay “behind” the attitude of the user towards domotics.

For this part of research a focus group consisting of nine seniors (between 55 and 75 years old) is used to gather relevant data to assess the needs and attitude towards smart technologies and what the underlying motives and influences are. The focus group procedure is based on the triangulation of longitudinal group discussions, enabling techniques and in-depth interviews during two years. The members of the focus group did not have any direct experience with domotic homes. Through workshops and several visits to domotic projects, the group became acquainted with the subject step by step, from a basic to a more advanced level. Depending on the goal and subject of a group session, a questionnaire was used to guide the discussion. The discussions were supervised in an indirect manner, i.e. by means of an appointed chair within the group. This was done with the intention of getting the participants to be more spontaneous; and to inspire them emotionally with interaction to generate more ideas in order to define the underlying motives of the members. To avoid the disadvantages of the discussion method such as the leader effect, group influences and social desirability answers prior to each workshop, before respondents could be influenced by the opinion of others, members were asked to fill in a questionnaire or form (a combination of open and closed questions) for example about the appreciation of domotics applications or type of information and guidance the seniors would expect if appliances were installed. During the individual in-depth interviews in order to trace needs, an “interview-guide” is used in which the answers to the questions are classified in a limited set of concepts: goals, activities, current problems and their expected problems in the future. Engel et al. (1993) state that a need is caused by a discrepancy between the current and desired situation (i.e. from a feeling of anxiety to a feeling of safety), and that the recognition of needs depends on the extent of this discrepancy. One way to illustrate this discrepancy and the “mental pictures” of the “desired situation” is by allowing the respondents to draw. In this investigation, the enabling techniques are used in two workshops to let the members of the focus group freely draw their “Desired Dwelling”.

The qualitative part of this investigation is followed by a mailed survey that is spread amongst 2000 seniors in the Netherlands. Response rates was 27% (n=542) which represents the Dutch population. With this survey the results of the qualitative research are tested, subsequently, the possibility of generalizing the results in relation to seniors living in the Netherlands is examined. By means of factor analysis three constructs (needs, perceived advantage, and perceived disadvantages) have been identified as significant diviners of the attitude towards domotica. The youngest respondent was 55 years old and the oldest 77 (M= 64.1 years old; SD=5.8).

Finally, based on the results collected from both methods, the characteristics of the desired domotic home is developed. These are translated into building technological characteristics and adaptations for the design of pilot projects.

4. RESULTS OF RESEARCH INTO ATTITUDE OF THE SENIOR CITIZENS

From the empirical research, it seemed that the seniors were generally acquainted with domotic applications and were informed of the benefits and added value of them.

However, they did not have any actual experience with domotics. The user-needs analysis pointed out that seniors do not basically reject domotics after becoming more acquainted with domotics and gain knowledge of the products, but are “sitting on the fence” and very critical towards it. However, it appears that seniors are positive about possibly purchasing domotic applications in the future.

In this investigation, large individual differences were discovered in the residential seniors’ needs; it seems that the seniors’ background characteristics (personal, environmental, and informational characteristics) have influence on the determination of their attitude towards domotics. For example, seniors with a lower education more often indicated that they needed domotics, while seniors with a higher education maintained a much more critical approach.

The investigation indicated that the senior was not convinced of the added value of the offered functionalities for his or her current life. The cost-benefit analysis is therefore negative. No particular domotics function has been considered by senior citizens as the “killer-application”. Hence, the current domotics applications are not attractive enough to make the breakthrough feasible. The study also led to the conclusion that by weighing up perceived advantages and perceived disadvantages during the decision making process, the benefits and affinities have more influence on the seniors’ attitude than the disadvantages, fears, and resistances. In the perception of “advantages” to senior citizens a shift of accent to now and here take place. At the moment, seniors are not prepared to invest in an application which they, according to themselves, may possibly need in the future. Also, the “effort” seniors have to make are averagely weighed heavier by age, which could make people more critical with regard to the benefit that is returned. For this reason, it will cost extra energy to convince seniors that domotics appliances have advantages for them in the present rather than just possibly in the future. It also appeared that the needs of seniors have a positive relationship with their attitude and “readiness for response” towards domotics.

Until now, domotics can be characterized as a mismatch between technology and the target group’s needs; through the supply-driven approach, more “variation” has occurred rather than “innovation.” For further development and a breakthrough of domotics, the functions must not only be matched with the actual needs of seniors in a better way, but also the possibilities and added value of domotics must be more clearly demonstrated. This is a great challenge for developers of domotic applications. This does not so much concern the acceptance of healthcare functions, where usefulness and necessity are recognized by the senior, although its realization is postponed to “later”. It concerns stimulation of interest in functions which are supporting for independently living, by contributing to the sense of safety, well-being, and increasing of comfort.

The solutions currently available do not live up to the senior’s needs and requirements. When seniors indicate preferences for domotics applications in the current situation, they choose for applications that improve the comfort (automated lighting (53%), vacation button (38%)) and safety (fire alarm (71%)). Care related applications (such as panic alarm and tele-medicine) currently do not score very high; although with regard to adoption in the future, applications that involve safety and care are chosen more often. This counts for example for the intercom which moves from sixth place to second place and for the panic alarm which is found to be redundant by 73% in the current situation.

Improvement of residential comfort, in the sense of absence of discomfort, contributes to the extension of independent life. Current domotic applications are however namely aimed at alarms, security, warning, and safety. It seems that seniors are sensitive for ease and improvement of comfort; they do not seem to reject domotics on those grounds. For example with the introduction and acceptance of the mobile phone, it was – after a period of rejection – the comfort (ease) which convinced the target group. Interesting is also the quickly increasing familiarity seniors show towards technology such as ICT; Internet usage amongst seniors has rapidly increased. All of the focus group members and 85% of the respondents that filled in the survey have an Internet connection.

The investigation into attitude also suggests that improving the comfort of seniors is a good starting point to familiarize them with domotics. For this reason, the investigation explicitly paid attention to the improvement of

the range of domotics applications from the basic appliances such as alarms, to improvement of residential comfort, as achieved by the multifunctional DCA-Wall.

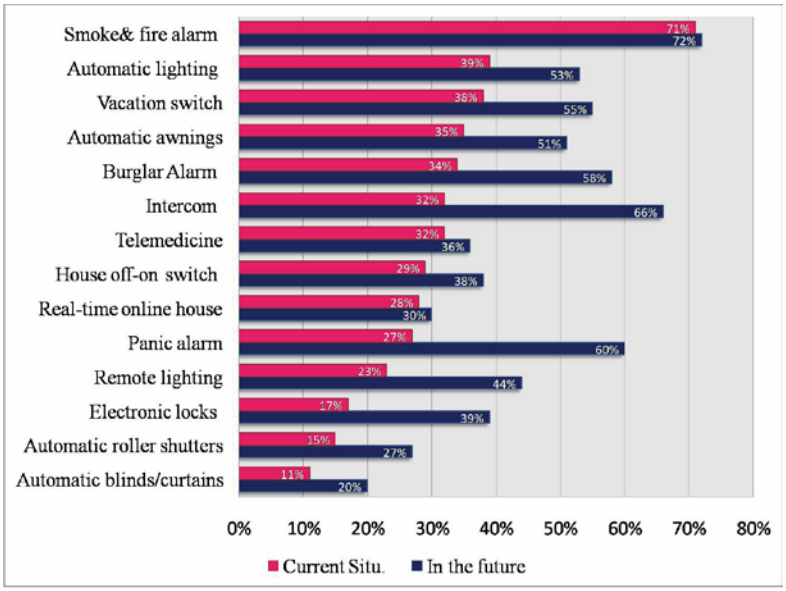

Figure 1: Attitude towards smart applications; in the current situation vs. in case of move.

5. INCORPORATION OF DOMOTICS IN THE ARCHITECTURAL STRUCTURE

This part of the paper provides for the association process of the desirable automation and available technology in the domestic environment of the older adults, i.e. the attitude and demand of the senior citizens are related to the perspectives and alternatives on the supply side and translated into the characteristics of domotics houses for the occupants.

However, the infrastructural facilities regarding implementation of domotics in existing dwellings are still a great challenge because of the lack of flexibility in the housing.

It is an expensive and radical task which concerns issues such as the manner of installing cables, keeping appliances out of sight especially because domotics must often be implemented at altitude (ceiling and wall). According to the senior citizens domotics in existing housing often disrupt the aesthetic image; wires often are in sight along the walls which is detrimental to the aesthetics of the house. In this respect, one speaks of creating (architectural) solutions and (building) technology to cover up (smart) technology. This project focuses on maintaining and enhancing the quality of housing over time, as related to environmental variables, and individual lifestyles. Extensive research is done into the ways that architectural facilities could be employed to enable seniors to age-in-place while maintaining their own lifestyle.

The goal of the project is the improvement of residential and wellbeing of the inhabitant that received a very high score in the research into residential needs of the seniors, and to give a solution for infrastructural problems of implementation of domotics into existing homes.

The Dynamic Comfort Adaptations (DCA) project is funded by the Province of North-Brabant (Dutch Provincial Government) and European Regional Development Fund (ERDF). The research group has a multidisciplinary setup and has integrated expertise on areas such as care, living, and technology to its disposal. This project was carried out in collaboration with professionals from housing and care corporation, domotics developer, service provider, Eindhoven University of Technology; the author of this article was project manager.

Hence, this case lays the foundation for the integration of domotics into the senior's domestic environment and confirms that an interdisciplinary (design) approach is indispensable for the merging of demand and supply on intelligent living environment.

Lichtenberg (2005) distinguishes four main phases within the product development process which are followed in this investigation: (i) the strategic phase; (ii) the creation phase; (iii) the development phase; and (iv) the realization phase.

The strategic phase of the development process of the DCA-wall consisted of (i) the establishment of the project organization, (ii) translating needs to performances and solutions (Design requirements and schedule of requirements), (iii) and a SWOT analysis of existing products and solutions.

For the case study, three teams were assembled: the research team (authors and the master students from the TU/e Department of Architecture, Building and Planning), the think tank group (consisted of professionals and the end-users), and the design and realization team (consisted of representatives from a company in the field of domotics, a product design engineering office, an office for product development and manufacturing, and the TU/e).

To make suitable designs, the relations between needs (why), functional performance (how), and technical performance (what) must be known. The needs and problems that are named during the research into demands of the seniors by the focus group, which led to the DCA-Wall product, are as follows: i) the product meets the needs for order and neatness, ii) the need for freedom in spatial arrangement, iii) needs for being able to perform ADL activities, iv) the need for thermal comfort, visual comfort, acoustical comfort, and rest.

Wireless connections could be a solution, however the reliability of such products is still questionable. So, keeping in mind the reliability of healthcare and services, choices were made concerning wired and wireless domotics appliances, the building technical implications were also analyzed.

These needs are translated into performances on which the product is developed. A concrete product idea is outlined during the creation phase by means of the following steps: generating ideas, synectics (selecting and developing ideas), preliminary design, elaboration and detailing design.

Based on this analysis and objective a product, the DCA-Wall is developed which is a secondary wall placed in front of a common party wall and only adds six centimetres. Common party walls are often the outer wall of a living room and this is where domotics applications specifically need to be installed. This wall system allows cables and insulation material to be installed between the primary and secondary wall. By allowing cables to lie in the cable ducts between the walls, sockets can easily be added anywhere along the wall without taking apart the entire wall. The entire infrastructure for domotics applications was installed behind this wall. The flexibility of the implemented wall allows for adaptation and upgrading of the home in the future.

One of the requirements of the DCA-Wall is the improvement of comfort. Attention was paid to the visual, acoustical, and thermal comfort of the resident in the design. An aspect of comfort is the aesthetical component: i.e. colour and design and the psychological impact of the product on people, the experience. In order to improve the visual experience of the user, an ambient light (RGB LED-lighting) was installed and thermal and sound insulation was implemented to improve the acoustical and thermal aspects. To improve thermal comfort a fast working electrical heating system is also integrated into the wall.

In this way, the product not only increased the residential comfort but also created an aesthetic and functional value. In the next stage, the plan and preliminary design (3D drawings) were discussed with the dwellers to ensure that their needs and requirements were met. In the realisation phase this wall is implemented in two pilot homes in Eindhoven (the Netherlands), which are occupied by seniors who were closely involved in the development and realization of the product.

The evaluation of the process and product took place from the viewpoint of integration of domotics in the building concept and the pattern of living of the senior. It seems that the occupants of the pilot homes are content with the DCA-Wall; there is barely any loss of space, and the implemented functionalities and aesthetic quality are highly valued. The multi-functionality aspect of the DCA-wall, by adding LED-lighting and heating elements, has positively influenced the seniors readiness to adopt, especially because these two functions have a clearly perceptible affect on the daily life of the user. Nevertheless, some issues were identified by the occupants. (Building) technological problems that were mainly come across included: the unacceptable amount of space in the meter cupboard, the compatibility of diverse systems (intercom and home control box), due to pending new

software for the integration of these domotics applications, a switch had to be made to a more conventional operation system. The case study showed that the occupants have a clear need to be “in control,” in other words, arranging affairs by themselves, changing settings, and being able to decide which applications to use and which applications not to use. Although this need is known, there is still an impression that domotics-developers do not recognize this need and often introduce half-developed, barely flexible products onto the market, that are not rightfully presented as advanced, user-friendly technology, ready for the end-user. Sadly it seems that in real terms many “empty promises” are being made by certain project partners.
However, this case study has shown that domotics applications are in an efficient and affordable way, feasible in the existing housing stock and the addition of functions to a product in this way is positively translated in the added value of the product. The applied technology can keep tele-care within reach, without having a typifying or stigmatizing effect on the occupants. This perspective can lead to completely new concepts for a living environment through which the current gap between demand and supply in the residential care provision can be bridged.

Figure 2: 3D- anisotropic section of the developed DCA-Wall

6. CONCLUSIONS

Despite the developments in ICT over the past decade, domotics has not made its breakthrough in the residential sector and is still in the pilot phase.
From technical point of view, a lot has been developed up to now, but a broad introduction never took place. As a product, domotics has not yet conquered the market, even though the possibilities are unlimited. Evidently there is stagnation on the route from developer to consumer. Research (Harper 2003, Friedewal et al. 2008, Mohammadi 2010) indicates that social, psychological and cultural, promotional and educational, technological, organizational and financial, and environmental challenges play an important role in determining the attitude and intention to adoption of domotics from the demand side and the implementation and diffusion from the supply side.
The application of domotics should be more demand driven, dynamic, and adaptable and should be integrated into the design of the house. This integration is of substantial importance for the acceptation and implementation of domotics. It concerns the way in which, the extent to which, and the procedure through which domotics is introduced into the dwelling and by means of that into the life of the senior. These factors together determine the extent of “empowerment,” through which the senior is equipped and is enabled to live self reliantly. Domotics has a great potential to ensure that people can age at home, but that it need to be implemented in a more natural and integrated way in the architectural structure of the dwelling. Respectively houses have to be prepared in a better way. At the moment that is not the case.

Functionalities should be better tuned to the actual needs of the elderly and the added values such as safety and wellbeing must be revealed.

As long as domotics is immediately associated with sickness and shortcomings, while seniors generally remain healthy for much longer, the breakthrough of domotics will not be occurring. The user-needs analysis displayed an increasing need for comfort in the sense of the absence/reduction of discomfort.

The occupant is concerned about living and residing as a whole, and not about the applications, the senior does not essentially purchase domotics but residential convenience and comfort.

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