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A Virtual Village Network Architecture for improving the elderly people quality of life

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Abstract Elder people often feel pushed to the margins by the generational shift and suffer from loss of identity and hence they lose motivation, recognition and self-esteem: they are often considered to be no longer capable of performing any service. This paper proposes an ICT network architecture oriented to improve the quality of life of elderly people and their caregivers focused on the user need satisfaction and reducing negative feelings like insecurity, vulnerability, loneliness and depression. This Virtual Village Network architecture is organized on 3 levels:

1. the Virtual Service Centre (VSC) that, through a proper home interface, carries out the support, the monitoring, the prevention and the social facilitation;

2. the Intelligent Domotic Health Networks (DHN) a domotic modular network with high local evaluation ability through which the VSC can monitor the home and/or the user's state of wellness and of health;

3. the Dynamical Village Network (DVN) that is an ICT network of users.

The idea is to build an ICT network of "virtual social neighbours" facilitating user relationships, able to have positive influences on the interactive abilities and self-image of the elderly, and to prevent or overcome solitude, isolation and their negative effects on the elderly person's overall quality of life and health. The whole architecture is pervaded by strict attention paid to security and privacy.

Keywords: AAL, ICT for Elderly People, Virtual Village Network, User Centred Network Services, Elderly Services.

1   Introduction

Currently about 16% of the EU15 population is aged 60 or over. As shown in figure 1, according to the baseline projection of Eurostat, this percentage will almost arrive to more than 29% in the year 2050. This means there will be more than 80 million people with various needs for care by 2050.

Moreover, due to longest life time of the oldest-old (over 80) within the last 50 years, this age group has become the fastest growing age segment in most European populations. This phenomenon is particularly evident for women. In metropolitan areas it is dramatically underlined: in Genova (Italy) , i.e, 48.7% of women over 75 live alone. Solitude and fear are common among the elderly. These feelings are experienced as interconnected;

both are threats to a decent quality of life in the third age, and tend to increase the risks of physical and mental health[1].

Often for old people, life events and psychosocial modifications can cause a decreasing in their social network with loneliness and isolation risks. Loneliness, lack of emotional support and lack of companionship or social support can leave elderly men and women vulnerable. Under the psychological profile relationship between depression and a life style lacking social contacts is well known. In [2,3] Cacioppo showed that loneliness in elderly people can be considered an health risk factor at the same level of obesity or smoking tobacco.

While the number of retirees who utilize social benefits is increasing, the adult workforce whose taxes fund those social benefits is decreasing.

ICT can help solve the problems of the growing number of elderly people in need of assistance. The development of domotics and of consuming electronics can greatly facilitate the management of the home and of daily life, if the systems are devised with simplified interfaces suited to the end user, and in such a way as to increase rather than limit the elderly person's social contacts.

However, to minimize these "threats" and perhaps improve these people's quality of life, action can be taken in the care for elderly people such as involving the social network and reducing the need of help with activities of daily living.

The Open University experiences (more that 3000 worldwide) have demonstrated how the participation to this kind of experiences have a positive influence on relational abilities, on the auto perception and, in general, on elderly people wellness. Such initiatives, in fact, have a strong socialising role. By participating to educational and cultural activities a series of expressive and relational capabilities can be developed. This allows an active life free from the filling of being emarginated by the society.
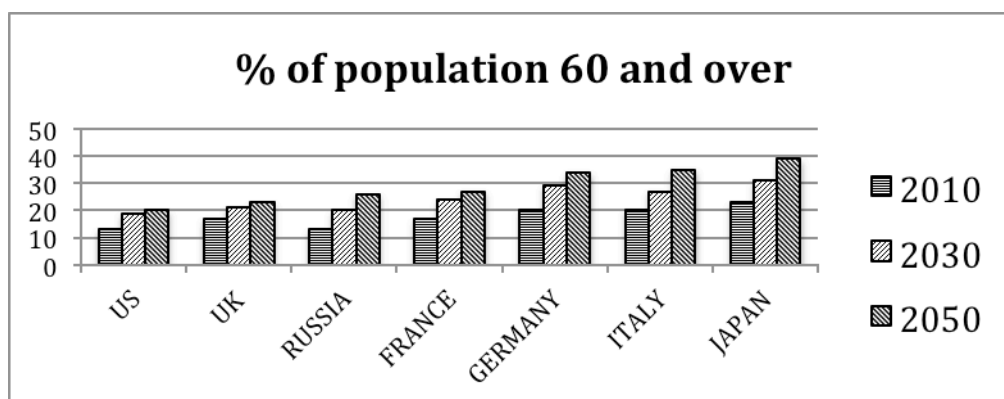

Figure 1. Percentage of Population aged 60 or over in some Countries. (Source: Commission Services (DG ECFIN), Eurostat (EUROPOP2010), EPC (AWG))

The essential and winning characteristics of these no-profit Organizations cannot be reduced to the vast educational choice offered; very important contributions are their easily accessible prices and especially their supply of the possibility of developing new personal relations. Unfortunately the participation to these experiences is sometimes limited due to practical logistic problems typical of elderly people (e.g. mobility problem), or due to the distance from the place where courses take place.

Technology is expected to aid in solving the problems of growing group of senior citizens in need of assistance. The elderly has been considered to be a special group with special needs.

In order to overcome the logistic problem of the Open University, a large number of initiatives are taking place in Europe, encouraging elderly people to use ICT and thus promoting e-Learning. in Northern Europe. However, to date there has been very little co-ordination or sharing of knowledge between initiatives and little follow-up. Moreover most of them were focused only on the e-learning aspects neglecting the social interaction aspects.

Specifically designed ICT based assistive technologies can be of great benefit to older people that are increasingly at risk of having functional difficulties in areas such as mobility, vision, hearing and in some aspects of cognitive performance. Many solutions for smart housing, independent living and technology for elderly have

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[1] Available at: http://europa.eu/epc/pdf/2012_ageing_report_en.pdf

been created to fulfil these expectations. Unluckily assistive technology often is not accepted by old users. This may be due to an incorrect prescription of technology or to a too great a burden imposed by its usage. Often, however, the stigma plugged to an assistive product could be an important reason for the rejection.

2   State of art

Many solutions, both academic and commercial, are presented to provide a better life for older people and to be able to reduce health costs. Since 2008, the EC funded an activity specific for elderly people within the Ambient Assisted Living Joint Programme (AAL JP). The aim of this call for project was the enhancement of the quality of life of older people and the strengths of the need to let the elderly people to stay home as longer as possible through the use of ICT. Some very interesting projects have been launched. I.e. CommonWell through the development of tools of telemedicine tried to ameliorate the user satisfaction and the services efficiency ; DREAMING tried to ameliorate the home care service through the usage of monitors ; ISISEMD ('Intelligent

System for Independent Living and SElf-care of seniors with cognitive problems or Mild Dementia) developed some services on monitor touch screen and satellite phone ; LLM (Long-Lasting-Memories) developed a test bed to promote the physical movement to prevent elderly disease ; SOCIABLE for elderly people with cognitive problems propose memory exercises through ICT devices; CLEAR (Clinical Leading Environment for the Assessment of Rehabilitation protocols in home care) proposes specific e-health home services ; Home Sweet Home promote the communication among users and their relatives and friends through cellular phone of videoconferences.

The Horizon 2020 EC Workprogramme 2014-2015 contains many topics related to active and healthy ageing with ICT.

In the project Alarmnet (USA) real time and long-term monitoring using wearable sensors, continuously record the information to assist diagnosis and has medication reminders. We therefore notice stand-alone solutions which target specific needs of problems of elderly people, without addressing other complementary factors which are still extremely important. The risk of presenting solutions not entirely appreciated by the final user and of collecting non-reliable results is thus very high.

In this context some experiences have realised significant steps forward in the elderly people acceptance of new technologies, since they obtain substantially positive users' feed-backs after an efficient information campaign and when, elderly people can participate to the projecting phase[1].

Most of these very interesting project had a the poor impact for many complex reasons:
- usually elderly people have difficulties in cross-passing the "digital divide", and this contributes to marginalize them and have some difficulties in interacting with ICT instruments and informatics;
- if the technology of the assistance is widely not accepted by elderly users. The elder considers the ICT support as an extension (often difficult to use), as a stigmatised object, as something that defines him as a person 'lacking' of functionalities, needing of help. He/She fills as person which has lost, or is going to definitely lose, his own autonomy ;
- many solutions are generalist, and do not include a target population and their special needs. For example, in the elderly's case, interfaces must be simplified and all the tasks have to be intuitive without the necessity of huge memorizing process.
- numerous solutions are concerned with the physical side but neglect the psychological side;
- most solutions do not provide a global response, allowing the senior population to have only one centralized and simplified solution. The fact of having to interact with different products and solutions, in order to have physical monitoring and social support, increases task complexity, causing the elderly to abandon the use of those solutions;
- the level of acceptation of new technologies strongly depends from their level of intrusiveness. Elderly people usually are not familiar with new technologies and above all they hate loneliness: caregivers and nurses, relatives and neighbours, sellers and messengers are human contact opportunities. The automation of an house shouldn't risk to cut the few social contacts with other human beings that the user still have;
- experimentation of auxiliary domotics, which do not take into consideration the vast diversity among elderly people, does not usually apply to the needs of the single user. Proposals that go beyond the simple furnishing of assistance are rare. The market of "intelligent houses" often grows due to the technological offer rather than the analysis of the demand, thus leaving the essential needs of weakest sectors of the population almost unsatisfied.

Acceptance of ICT is a complex and multifaceted issue. Studies conducted on elderly people usage of IT technologies (PC, mobile phones, Internet) demonstrate how the reluctance of adopting communication technologies is not only due to a lack of skills but, also, to the absence of perceived advantages and benefits. The consideration of age-related changes in perceptual, motor and cognitive abilities is required to guarantee accessibility. However, awareness of the importance of these aspects must be coupled with the acknowledgment of the importance of the compensatory processes that older people develop to adapt to the changes, and by the crucial role played by motivation, affection, and experience ("learning by doing") in supporting them. One of the primary goals of the Virtual Village Network architecture is to turn technology into something "familiar", i.e. furnishing interfaces that are perceived as belonging to their own world, that fit into their daily practices, and that can be interpreted and used exploiting common and practical knowledge acquired through experience.

3   The Virtual Village Network Architecture (V2N)

The Virtual Village Networks (V2N) vision see a group of elder users (virtual neighbour) connected through the Domotic Health Network (DHN) to a   Virtual Service Centre (VSC)   and to other user DHN composing Dynamical Village Networks (DVN). The Virtual Village Network (V2N) by connecting a group of elder users, or "*virtual neighbours*", allows the access to AAL solutions at home. The V2N architecture have been inspired by social life organization in the old Italian villages. In the past, within these villages, a 'physical' social network of personal relationships allowed even lonely old people to be integrated in the area where they were living [17]. They could live at their homes and take advantage of different kindness and communications from familiar and friend environment. If an old peasant had some problem, the village community could noticed it (i.e. because he did not go to chat at dusk on the door step) and could check for the causes giving an indirect surveillance. This ICT approach allows the monitoring and the automatic objective evaluation of the wellness status [6] and the effectiveness of the rehabilitation therapies undertaken at home [12] , with a minimum impact on the user. The archiving and management of these info in a secure repository allows the access and the evaluation by specialized medical staff able to promptly act in presence of alterations of the motor/cognitive activities, either caused by the worsening of chronic diseases or due to the effects of physiological aging.

The Virtual Village Network is focused on

- social interactions: although many assistive technologies can be incorporated, higher priority to ones facilitating social interactions is given

- User Involvement: by adopting a "user involvement" approach, V2N architecture actively seeks the participation of older people;

- Mutual assistance: due to the facilitate strong user interaction, the loneliness filling can be overcome and mutual assistive surveillance can be activates.
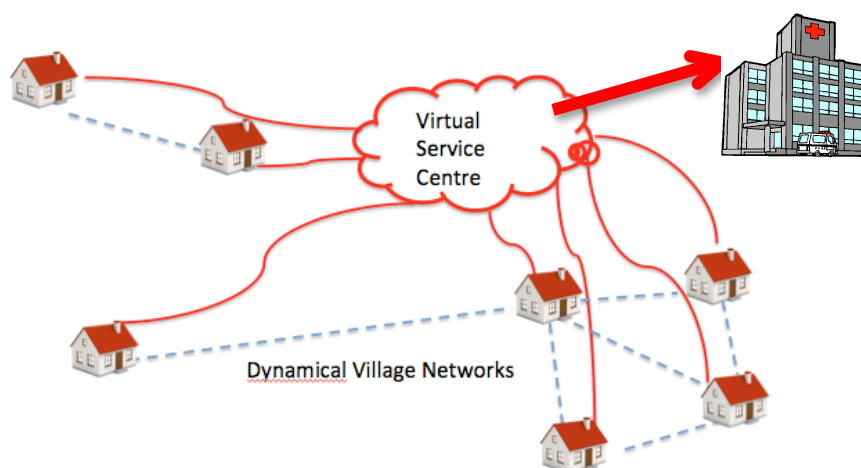

Figure 2 . The V2N Architecture. The Virtual Service Centre in connected to each user's home. Connection among users is a dynamical social network: it is subject to the temporary interests/ activities of the users like courses, games, events, chats etc. (-Dynamical Village Networks)

3.1   The Domotic Health Network (DHN)

The Domotic Health Network (DHN) is a local intelligent domotic system network. DHN acquires data from different types of sensors distributed in the house and adequately drives controllers and actuators [14] . This net is always active   and therefore it supplies the data necessary to the system through proper protocols. Through intelligent local evaluation of sensor data, it identifies the interaction level (normal, attention, call, emergency). The DHN for the old people should interface and focus on the following class of functions:
- o safety and security prevention from accidents – which quite often happen to old people
  - o remote monitoring: i.e. for protection of persons and goods alarm first management in case of fire, floods, burglary etc.;
  - o emergence management i.e. transmission of data necessary for activating the proper protocols in case of emergency (normal state, alert, request for help, emergency).
- o environment comfort: monitoring of the environment parameters correlated to the well-being of the old users (temperature, humidity, ventilation, heating, lighting, audio/video equipment, etc.);
- o health related surveillance: Telemedicine: monitoring of the main vital parameters of the old person, doctor contacts, medication administration nurse/caregiver services. These aspects are especially critical: they should be carefully customized in order to avoid useless or too binding implementations;
- o connection with the external world: Virtual Village Connection Interface, Network Services

Today sensor technologies cap pick up a wide spectrum of security, comfort and health related metrics. The sensors field both for healthcare and wellness application is 'going to explode' and big companies are going to invest on this business as Tim Cook said (CEO, Apple, 2013). The marked large availability of sensors need to be regulated by some standardization of their communication processes [4,5] , but is anyway going to enable the realization of new solutions. For example, sensors that tracks a patient's movements or steps are more reliable than a patient claiming to be following the exercise regimen that his doctor recommended or sensors knowing when a patient has swallowed his pill (and sends a signal to an app that emails confirmation to the physician) are more reliable than the patient trying to recall if/when he took his medicines. All the sensors/actuators in the DHN have to be tuned to meet the user's needs : they should be as transparent as possible or they should show very simple interfaces and have to be acceptable for the fragile users. The introduction of new sensors in the DHN has to be modular and should follow the elderly people help requirements that grow over the time[11]. Wireless connections (Wifi, blutooth) have to be preferred when it is possible [19]. The DHN activities should be carried out with respect to the security, the safety and the privacy of the user.
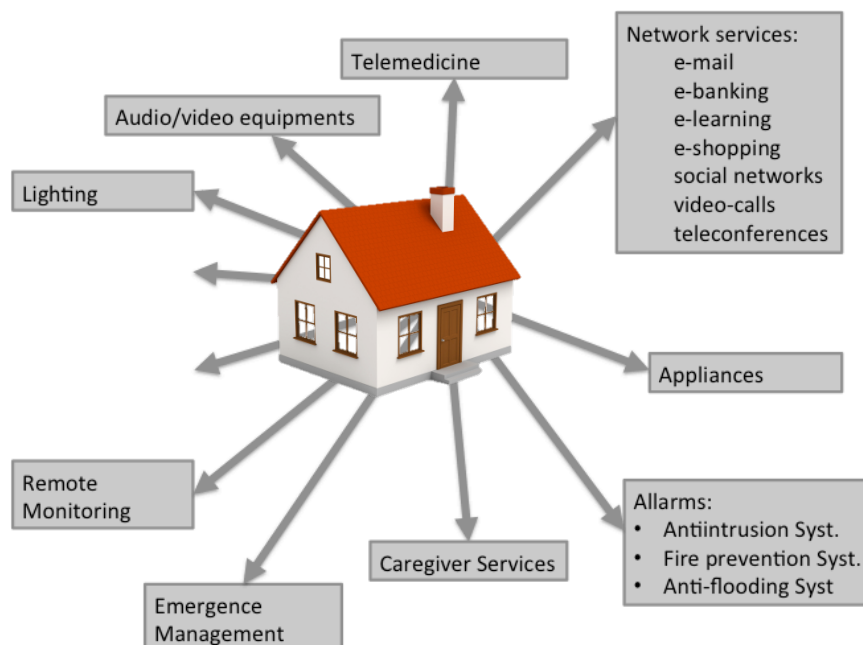

Figure 3. Domotic Health Network (DHN) Service Connections.

3.2   The Virtual Service Centre (VSC)

The VSC offers assistive services, but also opportunities for entertainment, creativity and learning in a friendly environment. It coordinates the activities of the users by offering them information on what is going on in the Virtual Village an on any other service available tuned on the user preferences and needs.. The VSC carries out the following functions:

o   Support: Organization of daily support (e.g. teleshopping, food services, cleaning/management of the home, caregiving services, physical rehabilitation [7], etc.) if and when necessary;

o   Monitoring:

    o   health parameter monitoring; caregiver supervision and connection to physicians processing

    o   alarm monitoring, etc.

    o   Management/validation of security control certifications

o   Prevention

    o   Cognitive games proposition

    o   Distribution/organization of information, options and suggestions for services, entertainment, lessons, meetings, conferences, shows, etc.;

o   Social facilitation

    o   Facilitation of access to useful information on what is happening in the outside community (suburb, city, country etc.), useful if the elderly user is mobile;

    o   Facilitation of elderly people's interaction by notifying the presence of other users connected to and able to be contacted through the DVN – subject to authorization from the people concerned;

    o   Organization/facilitation of self-organized games for users connected up in the DV2;

    o   Facilitation of ICT use;

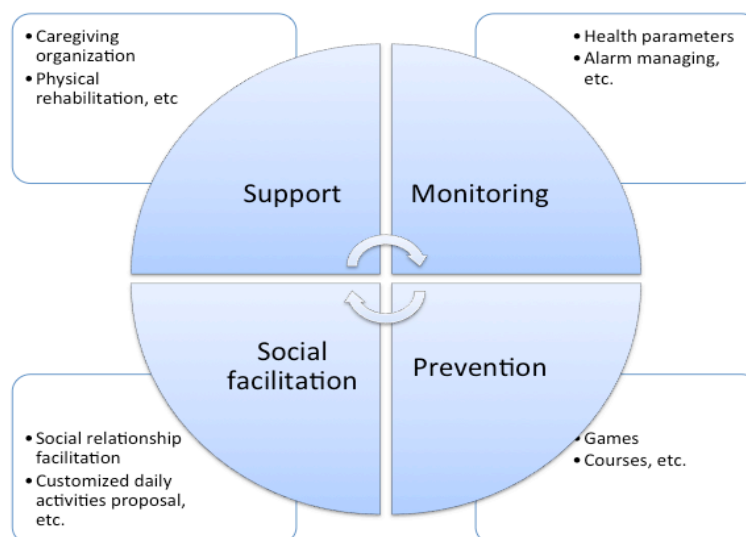   o   Daily communication with the user (if and when necessary);

Figure 4 The VSC Architecture

The VSC can be characterized by different levels of automation. Initially the VSC is a service managed through human intervention, supported by ambient intelligence techniques, which make it possible to choose the information to propose to the user on the basis of her/his interests and characteristics, through an adaptive interface.

A fundamental characteristic of the VSC is its "Virtuality". Operators are not supposed to reside in a specific geographic place; vice versa they can operate in various centres, or even while they are traveling, through e.g. the aid of video-telephones or palmtops etc. In such a way operations are simplified: a caregiver can take care in the house of an old person and contemporary he/she can help other users via data transmission). For the user the operator will appear and speak from a friendly interface like a video, a smartphone, a robot etc.. We can assume that some users of the system (old people still mentally strongly active, disabled persons unable to move etc.) can rise to the role of operator after some training, in a sort of "mutual voluntary service". Users expert in specific subjects can become teachers of courses offered on-line, always with a view to putting the elderly person at the centre of things as an active agent.

That contact with the VSC is also the minimal human contact that the elder person can have every day.

3.3   The Dynamical Village Network (DVN).

In the past, within the villages, a real social network of personal relationships allowed even lonely old people to be integrated in the area where they were living. They could live and take advantage of different kindness and communications from familiar and friend environment. If an old peasant had some problem, the village community could noticed it (i.e. because he did not go to chat at dusk on the door step) and could check for the causes giving an indirect surveillance.

The DVN is a partially protected network that connects users, facilitates communication with friends and members of the family and allows the creation of virtual communities, diminishing the risk of isolation. The DVN allows elderly persons to exercise their minds and above all to encourage and create significant relationships which will in their turn determine reciprocal informal monitoring similar to that present in villages in past centuries.

This network is an effective way of building self-help groups for elderly persons. Through this network, users can enjoy virtual meetings and can play with, speak to, and entertain one another, while providing reciprocal support: it is a system of distributed virtual presence.

Since this type of network is above all designed to be used as a place for sharing experiences and opportunities for meetings, the features guaranteeing service and quality are most important. To protect the elderly from thieves and swindlers, access to the DVN has to be supervised at various levels of security.

Through this net the elder users can stay in contact with each others (facilitated by the VSC proposals) and they can play, can use the connection to chat or to entertain themselves within a mutual support-monitoring the whole structure: this net is a distributed virtual presence system.

The DVN can help reducing the feelings of loneliness. It shall allow the elderly people to practice their mind through game playing, course following or delivering like in the Open University Organization.

The V2N facilitate also the communication with family members and friends, and allows the creation of virtual communities.

This network is an effective way of forming self help groups for older people and care-givers alike. The use of computers/ audio-video interfaces to provide social entertainment and to give access to courses and exercitation or to social games can help in fighting back loneliness.

Since this type of net is mainly destined to be used as a point of experience interchange and as an opportunity for meetings , the characteristics of guarantee and quality of the service should be stressed. The DVN should be a privileged 'place' where to meet old friends and where to find new ones: so far anyone who desires will be allowed to access the DVN, using weak methods of authentication. The system should notify through opportune marks the elder user if the person that is speaking with, is known to the network management or is an external element. This is to try to protect elderly people from cheaters and bunch of crooks. The reference idea is to have a kind of club for independent users who can tele-meet people or watch and discuss a movie or tele-participate to a conference or to a lesson according to their tastes and their health status.

The old person can join the V2N when He/She is still a self-sufficient person. In this phase the system help can be limited to daily audio-video contact with proposal of activities, occasions of socialization, exchanges with other persons of different ages. Subsequently, when the conditions of the old person changes, the operator will be able to activate more services.

3.4   Security and safety

Every time we have a network communication there is possibility of tapping, with the consequence of
information robbery. Therefore it is necessary to choose the appropriate mechanism for data authentication and
protection. This practice is important for any ICT system, but it is even more important for networks and services
that involve elder users. Senior citizen needs to know for sure who is his interlocutor, whether he/she belongs to
the operators group, or is one of the users, for instance; he/she needs to have the opportunity to communicate
consciously with external people as well. The network architecture has to be designed with big effort to the choice
of the technologies which allow to create safety channels protected from intrusions among the different gateways
and the Virtual Service Centre Safety is an essential attribute of any technological service responsible for the well
being of human beings.

As for safety, a key aspect is enhancing the trustworthiness of the systems such that in no case the users be
jeopardized. Moreover security should take into account other parameters of the system, like scalability, costs,
bandwidth available and power (both in terms of CPU power and battery power of wireless devices, for example).
This objective can be pursued by introducing a technology that allows the usage of procedures of secure
identification and safe access to the resources (opening of the doors, turn on of several monitoring devices and/or
other facilities) by means of the concession of the necessary privileges to caregiver (authorization). Note that
these requirement cannot currently be satisfied by using the usual methodologies (i.e. to make a copy of the house
keys), because in such a way the control of 'who has made what' becomes impossible (problem of multiple
copies). Instead it is important to guarantee the access to the resources only at some times, maintaining a log of
each single transaction, shrinking or increasing the authorizations following specific events (unexpected diseases,
out of order events to the house systems, ordinary maintenance etc.).

Just like safety, the reliability of the system is another very important aspect, so that the users do not run the
risk of a dangerous situation occurring. Security must also take account of other system parameters, such as
scalability, costs, available band and consumption (both in terms of CPU power the battery power of wireless
equipment for example).

4   Conclusion

The automation of a domotic house shouldn't risk to take away the few social contacts an old user still has with
human beings. A Virtual Service Centre (VSC) and a Dynamical Village Network (DVN) can give human
support helpful for both user and caregiver. This system will be tailored for the target audience, i.e., elder people,
trying to make use of terminals and concepts that are well known and accepted by them.

Assistive technology is not just to enable an older person to live alone, but to maintain autonomy and
relationship not only with his or her family or caregiver, but also with other people. In this paper an architecture
that allows the elder person to live at home as long as possible maintaining an acceptable independence state, a
good quality of life and a sufficient level of social communications is described. The focus of the V2N
architecture is based on human aspects of the elderly people needs. to improve the quality of life of elderly people.
The final goal is facilitating an independent and not isolated, social life, inside one's home as long as possible.
Contextually this architecture tries to facilitate the job of the caregivers allowing the communication with the
elders and supplying the attendance with a smaller workload.

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