Virtual communities for elderly healthcare: user-based requirements elicitation

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Abstract: Virtual communities for elderly healthcare have a potential to improve the community building process and to facilitate care services through support for activities, participation and information needs. This paper expounds on this idea by proposing a mobile virtual community (MVC) platform for elderly healthcare based on a services concept. The requirements for this platform are elicited using a method based on in-depth interview sessions with clients and caregivers in a care institution, a workshop with multiple stakeholders, and scenario-based user need analysis. We focus on the technical platform that is intended to fulfil the requirements elicited from this approach.

The platform is an extension of our existing MVC platform architecture, based on service-oriented principles. It enables user-tailoring through an adaptable set of mobile and platform services. We describe the platform and discuss its current and novel services as distilled from the requirements elicitation.

Keywords: virtual communities in healthcare; mobile virtual communities; MVCs; telemedicine; e-health; requirements elicitation; elderly healthcare.

Reference to this paper should be made as follows: van 't Klooster, J-W., van Beijnum, B-J., Pawar, P., Sikkel, K., Meertens, L. and Hermens, H. (2011) 'Virtual communities for elderly healthcare: user-based requirements elicitation', *Int. J. Networking and Virtual Organisations*, Vol. 9, No. 3, pp.214–232.

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1 Introduction

In the past few decades, the demographic trends in western countries are characterised by aging populations, growing life expectations, decreasing number of healthcare professionals, increasing cost pressure on healthcare systems, and urbanisation. These factors have increased workload on the sector of *elderly care* (Broens et al., 2007). Services in this sector include daily need services such as providing meals, washing, supplying medication, etc., as well as frequently occurring tasks such as ensuring the health status of the clients, providing assistance in case of emergencies and reminding about the client's agenda. Apart from providing these basic needs, other important responsibilities of the caregivers are fulfilled on a less ad-hoc basis. These responsibilities include providing a daily structure, being a conversational partner, and enabling activities and participation (i.e., in society) for elderly.

Nowadays, *information and communication technologies* (ICTs) have revolutionised daily living, communication and behaviour of people with applications in almost every aspect of life. ICT is effectively used for socialisation by means of virtual communities. A *virtual community* (VC) is an ICT-mediated social network: it is defined as a group of people who have regular social interaction, independent of time and space, because of a common goal such as a problem, task, or feeling exchange (Rheingold, 1993; Eysenbach et al., 2004). Virtual communities are in use in various domains including computer supported collaborative work (CSCW), sport associations, contact between teenagers, and healthcare. The goal of a VC is to support interaction between members.

ICT in healthcare is also referred to as *electronic health* (e-health) (Eysenbach, 2001). E-health is an emerging field in the intersection of medical informatics, public health and business, referring to health services and information delivered or enhanced through the internet and related technologies.

According to the definition, virtual communities can be used to support many processes in the elderly care sector. For example, they support the social interaction between clients and (informal) caregivers. ICT-based synchronous and asynchronous communication may expand client and (in)formal caregiver communication methods. VCs allows for the exchange of public and private information between involved parties and services. Profile- or context-based matchmaking allows for suggestions to find friends, activities and services. Reminder and agenda services can be moderated by and tailored to community members to increase and to organise socialisation. A VC can give personalised medication reminders and compliance rates when connected to medication registration. When mobility is integrated as in our case, ambulant telemonitoring services can be integrated for physiological signal monitoring and for feedback purposes.

According to these examples, virtual communities have the potential to improve the community building process and care services through support for activities, participation and information needs. As we will see in the next section, only a part of this support is however currently realised in practice. Moreover, such virtual communities need to be tailorable and composable, because the elderly is not one homogenous group and needs will vary from individual to individual.

The contribution of this paper is a systematic development of virtual communities for elderly. To this end, a multidisciplinary and user-centric approach is followed where input is gathered and processed from care clients and caregivers using in-depth interviews, and input from other stakeholders are incorporated in the development process. This paper discusses requirements to be supported by the VC. Based on these and earlier experience in virtual communities in the healthcare domain, we describe the technical platform that fulfils these requirements for the elderly healthcare domain. Our target domain consists of elderly of 60 years and older, with varying levels of care needs, living independent or in open accommodations. In this paper, we focus on the requirements and services of the technical platform rather than on the graphical user interface.

The remainder of this paper is structured as follows. Section 2 discusses related work. In Section 3, the methods that were used for requirements gathering are explained. In Section 4, results of the interviews are discussed. Section 5 presents the proposed mobile virtual community (MVC) platform and services. Finally in Section 6, conclusions and future work are presented.

2 Related work

The application of ICT in healthcare is often referred to as telemedicine or e-health. Telemedicine is referred to as providing medical services over geographical or time distance, and can be used for applications such as health maintenance, alleviation, cure and prevention of diseases. On the other hand, e-health can be considered more broadly as an emerging field in the intersection of medical informatics, public health and business. E-health refers to health services and information delivered or enhanced through the internet and related technologies. In a broader sense, e-health characterises not only a technical development, but also a state-of-mind, a way of thinking, an attitude, and a commitment for networked, global thinking, to improve healthcare locally, regionally, and worldwide by using ICT (Eysenbach, 2001). In e-health, there is a great interest in the deployment of patient care information systems or personal health records to improve service and administration.

ICT-innovations like VCs have become very popular (e.g., Facebook). VCs provide people not only with information, but also with emotional support and a place to share their personal experience (Rheingold, 1993). VCs are also studied for healthcare purposes. In healthcare, virtual communities can be divided into four types (Demiris, 2006):

1 communities for healthcare professionals only

2 for patients/informal caregivers only

3 combinations of them

4 general public communities.

Members of a VC can of course be a member of multiple communities or other VCs according to their preferences. It is however suggested that a single community has a clear focus (van Beijnum et al., 2009; van 't Klooster et al., 2010; Maloney-Krichmar and Preece, 2005). This is different from another e-health application area that of personal health records or patient cares information systems (Berg, 1999). These are in general large, closed and complex systems with general-purpose functionalities, and increasingly based on complex standards such as HL7.

Several scientific trials have been performed w, but there is no solid scientific evidence of the advantages of VCs. One reason of this lack of evidence is that most of these trials are combined with quite complex interventions. Promising is the fact that no negative findings have been recorded either (Demiris, 2006).

VCs allow people to find and interact with new friends, though a common interest alone is often not enough to form the basis of new friendships. Especially those who tend to have little cohesion with the community they frequent, stay only for short periods of time and visit less often. Posters on forum-based communities have a more intense connection with the community and are more likely to enrich their social network by means of a VC (El Morr and Kawash, 2007; van Uden-Kraan et al., 2008; Seniorenweb, 2009).

Maloney-Krichmar and Preece (2005) have reported on an in depth investigation on sociability, usability and dynamics of the Kneeboard online community. They observed 3 factors that impact the success of a VC: robustness, a narrowly focused purpose and the social context of the community (specifically the mix of stable long-term members and newcomers).

There are other examples of VC projects. *SeniorenWeb* (Camarinha-Matos and Afsarmanesh, 2002) is an online VC for elderly. It provides members with mail groups, interesting links for elderly and activities such as group meetings and courses, however it does not provide personalised health-related services. *TeleCARE* was a European project, (Camarinha-Matos and Afsarmanesh, 2002) focusing on a communication infrastructure for tele-supervision and tele-assistance. Older projects supported simple social information exchange (Wellman et al., 1996) between participants, and socialisation through instant messaging (Furlong, 1989). However, research on requirements elicitation for VCs that support a *services* concept (being, e.g., mobile, ICT-mediated or personalised) for elderly healthcare is limited.

Apart from this, the combination of ICT and medicine offers new ways to deliver health maintenance and disease prevention, alleviation and cure, which were not possible before ICT was available. Especially with the advent of mobile communications, ICT allows health support anywhere, anytime. With respect to VCs for healthcare, ICT state of art enables development of health support and socialisation, beyond simple chatting and information providing. In this paper we describe how this can be realised, involving end-users and scenarios.

3 Methods for requirements elicitation

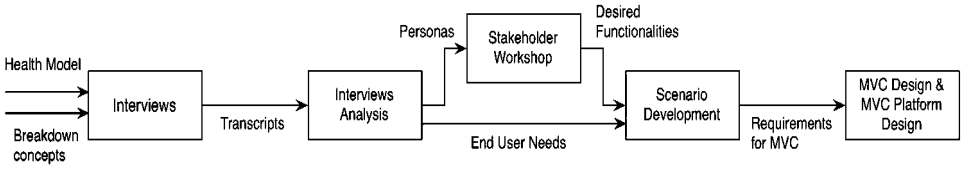
Our requirements elicitation process combines scenario-based user need analysis (SUNA), and interviewing techniques guided by a health model constructed from the

International Classification of Diseases (ICD), the International Classification of Functioning, Disabilities and Health (ICF), and their relationship as defined by so called *core sets* (WHO, 2004; WHO, 2001; Stucki et al., 2004). Section 3.1 gives an overview of the requirements elicitation process steps taken. Section 3.2 discusses the health model. Section 3.3 details the interview design and Section 3.4 discusses the SUNA.

3.1 Overview

The requirements elicitation process that we followed is shown in Figure 1. The boxes show the activities; the arrows denote the information used and produced for those activities. A health model and breakdown concepts were used for interviews with clients and care professionals. Analysis of the interviews was used for scenario development purposes, both directly and involving a stakeholder workshop. The scenarios consequently imposed requirements on the MVC and its platform. Hereafter details of each of the steps are given.

Figure 1 Steps taken to gather requirements for the VC



3.2 Health model

The interviews are the starting point of the requirements elicitation. In order to structure and guide the interviews, relevant health related issues need to be identifiable. To prepare, execute and analyse the interviews we adopted a comprehensive health model.

The WHO has defined a holistic ontology for health, called the ICF (WHO, 2001). This ontology of health is a bio-psycho-social model of health, that can be used for many different purposes, among these the assessment of the health condition of man. The ICF defines the health condition as a composition of four components: body structure, body function, activity and participation. Each component comprises a set of categories.

Example categories are: S4: *structure of the cardiovascular, immunological and respiratory systems* and D3: *communication*. Categories may be organised in a hierarchy of subcategories, for example: S4 includes amongst others the subcategories s410 – *structure of the cardiovascular system* and s420 – *structure of the immune system*. D3 includes amongst others *communicating – receiving* (d310-d329) and *communicating – producing (d330-d349)*. Because of its bio-psycho-social model and its detailed description of both medical and social factors, the ICF is a holistic model.

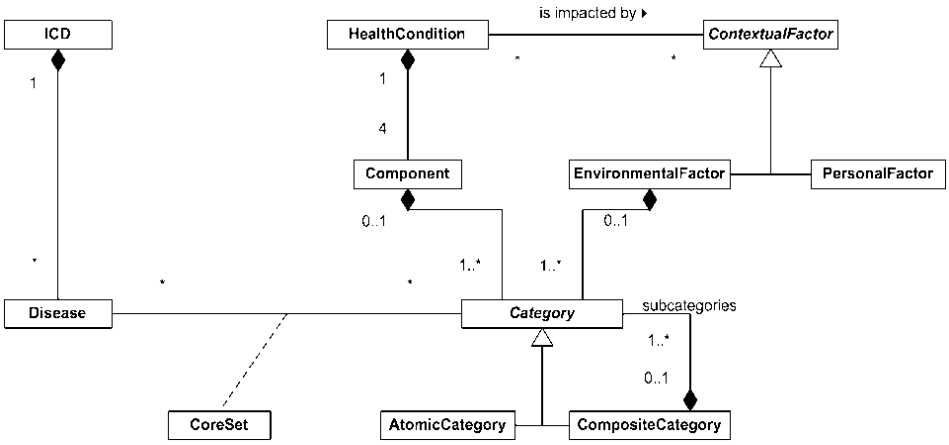
The ICF components are influenced by contextual factors, which can be either personal factors or environmental factors. The ICF defines the relevant categories for environmental factors.

Using the ICF, we are able to assess a client's health status. Moreover it enables the structuring of interview sessions and the capturing of the essential client's needs and

values related to all health aspects. Therefore we used the ICF as a theoretical basis of the interview protocol.

Most of the clients in our target group have been diagnosed one or more chronic diseases. A taxonomy of diseases is available from the WHO's ICD (2004). The qualitative relation between a (chronic) disease and the ICF categories potentially affected by this disease are defined by a, so called, ICF core set (Stucki et al., 2004). Core sets have been defined for about ten chronic diseases. The conceptual schema of the ICF, ICD and core set is shown in Figure 2.

Figure 2 Comprehensive health model



3.3 Interviews

Throughout three days, we interviewed seven clients and four care professionals in the elderly care centre 'Parc Hoogveld[1]' in Sittard, the Netherlands. The interview protocol was designed to get an in-depth understanding of the health status and living situation and to elicit care values and needs. The protocol had been tried out in advance in a test interview. The number of interviewees is low, and therefore does not deliver theoretical saturation (Glaser and Strauss, 1967). However, this is not the aim of this study, instead it serves as a first iteration of end-user input for development purposes and for an in-depth understanding of the behaviour of members in the target group. A second iteration of end-user input is discussed in the next paragraph.

Members of the target group have age 60 and older and have two determinants in common:

1 they have varying care needs due to varying health problems

2 they make use of different care services from the care organisation.

They were recruited on voluntary basis by the care organisation. The care organisation assured those two determinants and representation of the inhabitants in the centre. Beforehand, we studied information about the clients' health conditions and care services they use, by means of examination of their personal intake assessment, for which permission was obtained.

Two of the interviewed care professionals were responsible for providing care services to clients. Since the two caregivers were interviewed after the client interviews, we were able to reflect and discuss the answers from the clients with the caregivers. The third care professional was responsible for client intakes and updates, to determine care services to be provided to the clients. The fourth care professional was specialised in information management in care centres with a strong care giving background.

The clients were asked about a couple of items. Their health status was discussed, based on their intake assessment and the relevant ICF and Core Set categories. We also discussed their information needs, use of technology, care services received from the care centre or elsewhere, and wishes for novel functionalities that could be supported by means of technology.

The caregivers were asked about their working procedures, information needs, use of technology, care services provided by the care centre and existing working practices.

The in-depth interviews were held in a semi-structured manner and were recorded and transcribed. The interview protocol was based on the health model discussed in Section 3.2, and on breakdown analysis. In breakdown analysis, (Hettinga, 2002) the focus is on analysis of interrupted, not smoothly proceeding equipment use, e.g., technology equipment. We used breakdowns accordingly when asking the clients about their use of technology, and when asking the professionals' view on this. In the interviews with professionals, we used breakdowns when they showed us their equipped working environment.

The completed interviews were transcribed and then analysed. Analysis was conducted by identifying actualities in the answers and comparing these with other transcripts, so as to retrieve the key actualities. This grounded theory (Glaser and Strauss, 1967; Corbin and Strauss, 1990) based-analysis technique was used to retrieve the end-user values and needs discussed in the next section.

3.4 Scenario-based user need analysis

In situations where the use and purpose of a novel system are not clear a priori, usage scenarios are an appropriate technique for gathering these requirements (Alexander and Maiden, 2004; Sutcliffe, 2003; Hsia et al., 1994; Robertson, 2004). As this is the case in our project, SUNA (Hsia et al., 1994) was used to elicit functional requirements.

The interviews with end-users (clients and care professionals) were transcribed and analysed. Based on the key health problems, values and needs, three *personas* were constructed. Personas are fictional persons that serve as a vehicle to illustrate envisioned use of technology in scenarios (Cooper, 2004; Pruitt and Grudin, 2003). They represent role models of the target group of elderly. These personas were constructed blending idiosyncratic details of different interviewees into three persons with a combination of features that suited the main purpose – to serve a role model in the workshop, clarifying and illustrating the key findings of our field work. To ensure this coverage, we checked whether the interviewee characteristics were represented in the personas. Once constructed, the personas were introduced in a multi-stakeholder workshop.

The workshop centred around two multi-stakeholder focus groups with professionals from care, academia and home automation industry. All are members of our project consortium. The workshop identified a collection of functional elements of future ICT technology use for the targeted elderly.

The interview analysis resulted in end user needs. These are presented in Section 4.1. The end user needs, prioritised by the consortium, and the functional elements, formed the input to develop three scenarios. They were drafted to present the proposed novelties in a coherent story around the personas. Then, the project consortium reviewed the scenarios to achieve consensus on the envisioned system.

The requirements were grouped in basic (overall) requirements and requirements related to a specific function to be fulfilled by the system. For traceability purposes, we listed from which scenario each requirement was inferred. Finally, we checked

1 whether the scenarios together covered the list of desired functionalities from the workshop

2 whether the scenarios covered the needs expressed by the clients and care professionals.

4 Results

4.1 Interview results

Table 1 summarises the needs and values put forward by the clients resp. care professionals during the interviews. These findings were not explicitly asked for, but mentioned spontaneously by the interviewed persons. One client and one caregiver emphasised the importance of finding new friends to conduct activities with. Three clients and four care professionals mentioned the importance of remembering and information on events. Six clients and two caregivers recognised medication support would be useful. Almost all clients (6) used, or wanted to use, some technology for hobby, such as cellphones, multi-button remote controls, dvd players, but also computers. For instance interviewee 1 said[2]:

> "Yes, I would like to learn how to handle a computer. I think I could do that ... from somebody, one-to-one. Not in a group, I'm not really a group person. If that would be possible..."

The aspect of learning how to operate the device is important, as addressed by interviewee 2:

> "My grandson then comes to explain me how to operate the dvd recorder."

However not all interviewees want to use a computer, afraid that it consumes too much time learning. Interviewee 2 states:

> "My son-in-law bought a new PC, with more capacity, and wanted to dump his old one on me. But I didn't want it. If you want to learn handling a computer, that is a lot of work, and I don't have the time to do that. I can handle the radio, the television, and the dvd recorder and that's all I need."

The use of technology indicates that the current generation independent elderly in our research do accept technology, but devices that perform computing tasks should preferably not look like a computer to receive higher acceptance.

We observed that clients talked frequently about their communities, e.g., concerning family, neighbours or relations with the professionals. Five clients valued contact with family, not only for themselves but also for their relatives. Interviewee 3 mentioned:

> "For instance, my sister calls every evening at seven, and she talks for the better part of an hour. She can talk about the past, for example about the business that we used to have."

Though contact with family was not addressed in two interviews with caregivers, the other two valued it as important too. Two clients reckoned having a daily structure or aid for that is important; 2 caregivers did so as well. Almost all clients (6) valued support from and to neighbours and people in their community as important. Regarding this contact with the community, interviewee 1 said:

> "It's a fine little street here. Yesterday we went in a van and a car to the hospital, all together, and then we drink coffee together and everyone is very happy."

> "And in the morning I pour them a coffee. In our sitting corner, I'm usually the first to be there, and then I ask everyone "would you like a coffee?" and then I give them one. There is nothing wrong with my hands, it's only the legs that give problems."

Apparently, these communities are valued as an important part of their daily life. Also three caregivers mentioned this as important for their clients. Three clients mentioned that when they would be introduced to new technologies, assistance and explanation of the usage would be important. The caregivers did not address this. Interestingly, the clients did not talk spontaneously about monitoring or being monitored, but all the caregivers addressed monitoring functions as important for the clients' safety. We think that this comes from the fact that for the caregivers monitoring of safety is an important aspect of the job (e.g., because of the possibly large impact after dangerous events such as a fall). On the other hand, for clients it is something they rather not think or talk about freely when it concerns their own situation.

Table 1 Values and needs important to clients and care professionals

Value/need	*Nr. clients reported (n = 7)*	*Nr. prof. reported (n = 4)*
Finding friends for activities	1	1
Providing daily structure	2	2
Information on events	3	3
Support for medication	4	2
Technology use for hobby	6	2
Contact with family	5	2
Memorising events	3	4
Contact with community	6	3
Aid in technology use	3	0
Monitoring for safety	0	4

Clearly, some of the needs and values found in the interviews can be supported by means of virtual communities. As there are various occasions in elderly healthcare in which different people interact because of a common problem or goal, different communities can be identified according to this definition. Because of their social nature, services for finding friends, information on events, memorising events, contact with family and

contact with the community, are also good candidates for VC functionalities. Moreover, these services can be enhanced using the social graph of the member once this graph has been established. Finally, we refer to earlier work (Pawar et al., 2008; van Beijnum et al., 2009; van 't Klooster et al., 2010) in which already scenarios related to monitoring for safety reasons are elaborated on and supported by means of virtual communities.

4.2 Workshop results

A project consortium workshop has been held in Enschede, the Netherlands, on 13 May 2009, to identify and select desired functionalities. The workshop participants (consortium members and external experts from care and ICT) discussed a range of functionalities intended for the personas. The proposed functionalities can be grouped under three service categories:

1 reminder and information services

2 social interaction and support services

3 remote monitoring and feedback services

The workshop also yielded an idea for an information and communication system that should play a central role. This software system, which we call *Julie*, supports two-way (video) communication, is able to present content and (interactive) information, eventually on request. Moreover, Julie can run on various existing devices such as a TV, PC or smartphone.

For each of the three service categories, scenarios are developed. They contain the desired functionalities and the needs addressed by the interviewees. Based on the scenario about social interaction and support services, functional requirements are elicited for a VC platform. This motivated us to extend the design of our existing MVC Platform to fulfil the requirements imposed by this scenario. Before presenting the most important requirements, we exemplify our intentions by presenting this scenario. In this scenario, the proposed technology becomes concrete through the use of the information and communication software system *Julie*.

> "John Pieters is 78 years old and living alone in a care centre. He developed chronic obstructive pulmonary disease (COPD). The treatment of Mr. Pieters' disease focuses on reducing symptoms and avoiding further deterioration of his condition. Some of his medicines work for the symptoms, but physical exercise is the key treatment. The original series of exercises was explained once at the doctor's office. Since then, Mr. Pieters conducts them at his home. During the exercises, he uses a finger clip, which measures the oxygen level in his blood and his heart beat. Through the wall mounted communication system Julie, he gets feedback on how long he should do each exercise, based on those measurements. Thanks to this, Mr. Pieters dares to continue exercises for longer than he would do otherwise. A COPD nurse uses the two-way video to check-up on Mr. Pieters monthly."
>
> "After those check-ups, the doctor may adjust the exercise levels and medication, based on to the acquired measures and progress of the disease. The COPD nurse also adds the next check-up to Mr. Pieters' calendar. Reminders for the exercises, the medicine and the meetings are sent to Mr. Pieters through Julie, either at home or (when he is underway) through his mobile phone. This is useful, as his memory is getting worse."

> "Alice is a kind caregiver, who regularly visits Mr. Pieters. Alice not only helps with the housekeeping in his apartment, but also checks up on him once in a while via Julie to see how he's doing. Julie suggests activities and new inhabitants for him to meet in the care centre. One new inhabitant turns out to be a friendly man, and Alice arranges they can have conversations through Julie. Afterwards, Mr. Pieters and the new inhabitant meet occasionally for a walk or a coffee."

In Section 4.1 we described that the clients talked about their different communities. Also from the scenario above we can identify the important notion of multiple communities for different goals. We see Mr. Pieters is involved in three different communities. The community that relates to his physical exercises includes the following actors: Mr. Pieters, the COPD nurse, and the medical specialist who has access to his training data and medication prescription. The goal of this exercise community is to support treatment for his COPD. The second community's goal is to support Mr. Pieters' in tasks and activities of daily living. The housekeeping, his agenda and the reminder service are key services here; these services are accessible by the caregivers and partly by the COPD nurse. The third community is for socialisation. Alice has been authorised to access Mr. Pieters social network, as she links Mr. Pieters and the new inhabitant such that they can socialise and make appointments for activities.

5 MVC platform

The existing MVC platform described in Pawar et al. (2008), van Beijnum et al. (2009) and van 't Klooster et al. (2010) basically integrates services on a web-based platform with services on mobile devices. However, to support the envisioned scenarios we developed, both modifications and additions need to be made to the existing MVC platform. First Section 5.1 presents the architecture of the current MVC platform, then Section 5.2 discusses the MVC Platform enhancements to support this research.

5.1 Existing MVC platform architecture

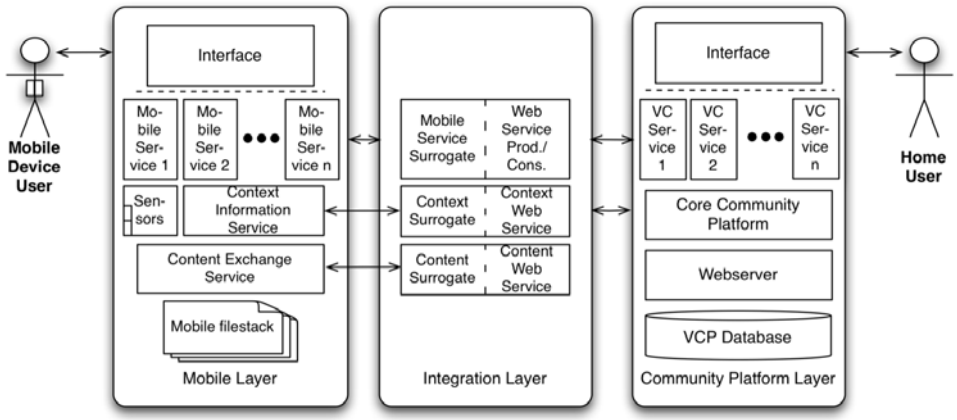
An overview of the architecture of the MVC platform is presented in Figure 3. In order to support mobility, three layers are identified:

- *Community platform layer (right):* The community platform layer is responsible for providing the VC platform services, e.g., the context-aware matchmaking service and storage.
- *Mobile services layer (left):* The mobile services layer is responsible for making available the MVC platform services to a mobile device and for providing services such as content exchange and context information services from the mobile device to the MVC. For example, it enables on-body physiological signal collection using sensors, delivery and context information from the mobile user.
- *Integration layer (middle):* Because of the use of different technologies at the platform services layer and mobile services layer, an integration layer is used to support cooperation.

The platform can be used by either the mobile user via the mobile services layer, or in the home, via e.g., a computer, laptop or high definition television to a more stationary user.

The three layers of the MVC platform in Figure 3 are described in more detail, starting with the mobile services layer.

Figure 3 Layers in the MVC platform



5.1.1 Mobile services layer

For the mobile services layer, we use the existing mobile services platform (MSP) described by van Halteren and Pawar (2006). An adaptable set of mobile services can run on the mobile device. Sensors, eventually placed on the user, can provide context information as well as a source for content exchange using a Body Area Network (BAN). The user may, if needed, interact with services via a graphical user interface, depending on the service evoked. If no internet connectivity is available, the mobile filestack is used as buffer.

MSP supports patient and caregiver mobility. The Remote Patient Monitoring System built on top of MSP is capable of bridging location and time for actor interactions. Furthermore, the system comprises generic components and facilitates the design and development of case-specific telemonitoring functionalities, such as physiological signal processing and distribution. Such case-specific functionalities have been developed for epileptic seizure predictions, neck shoulder pain monitoring, and cardiac patient monitoring. It builds on SOA principles implemented using Jini (2009) and uses the Jini Surrogate Architecture (2009) for solving the computational complexity problem of using mobile devices as service producers.

5.1.2 The Community platform layer

For the VC platform, we are developing the Core Community Platform (for core services) and VC services based on SOA approach (Papazoglou and Georgakopoulos, 2003). The goal is to provide a set of loosely coupled services, tailored to specific rollout circumstances. The services include:

- *Member management service:* This service includes the invited registration of new members, editing and managing member profiles, logging in, session handling, etc.
- *Directory and announcement service:* This service provides functionality for the community support providers to post news, list the offered services, and listing of events such as those leading to improvement in the psychological and physical health of the patients.
- *Alarm service:* This service enables alarms, based on a predefined level of urgency. In case of an emergency, this service can be used to notify for example a caregiver.
- *Community management service:* This service consists of all the functionalities required to create, join, access and search communities, (such as those of patients with a particular type of condition), publish, get and subscribe to information in the existing communities.
- *Policy making and enforcement service:* To enforce the interactions between an actor role and a service, as well as to take into account the trust and privacy requirements in the MVC community, a set of policies need to be developed and enforced.
- *Social interaction service:* This service handles the *one-to-one*, *one-to-many* and *many-to-many* interactions between the MVC members. This includes interaction functions such as instant messaging, group notifications, and subscription to a particular type of content (e.g., information posted by a caregiver).
- *Context-aware matchmaking service:* Semantic descriptions of the member profiles combined with description logic are powerful tools to perform matchmaking. The context-aware matchmaking functionality of this service could be used for example to recommend new members in the community, or to search for the nearest available caregiver.
- *Content exchange service on the mobile device:* This service on the patient's mobile device is aimed at sending the contents (e.g., text, images, and streams) generated at the mobile device to the community platform such that this content could be published in the community. Similarly, this service could also request/subscribe to the community content the user is interested in and present this content for user viewing.
- *Physiological signal monitoring service:* This service enables the monitoring of vital signs, such as blood pressure and oxygen saturation information using the MSP.
- *Context information service:* This service obtains context information (such as location) of the user and sends this information and subsequent context changes in real-time to the community platform. This information could subsequently be used by the context-aware matchmaking service.
- *Community service:* This service indexes and allows modifications on what services are available to which community.
- *Chat service:* As a sub-part of social interaction service, this service allows for instant voice, video or message chat amongst members of the MVC.

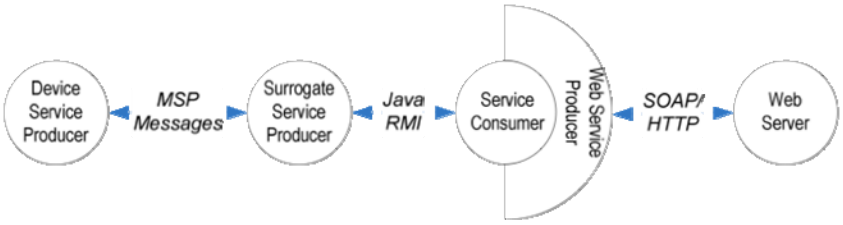
The user, e.g., an (informal) caregiver or client, can interact with these services via a web interface.

5.1.3 Integration layer

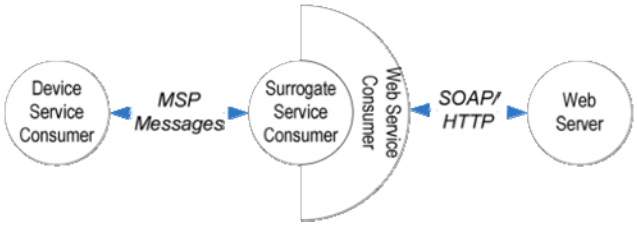
The purpose of the integration layer is to integrate the MSP and the VC Platform. The integration technology adopted is web services. This way, we maximise the reuse of existing technologies and platforms, and focus on the integration issues, and the specific aspects that are implied by the requirements from our case study in the care domain. In the following, each of these parts will be briefly discussed.

The principles of the integration are shown in Figure 4. A Device Service Producer is made available via its associated Surrogate Service Producer. A (Jini) service consumer binds to the Surrogate Service Producer and embeds a producer based on web services; this web service producer publishes its service to the community platform [see Figure 3(a)]. In the case of a device service consumer, the Surrogate Service Consumer embeds the web service consumer that binds with services provided by the community platform using SOAP over HTTP, see Figure 3(b).

Figure 4 Service integration: (a) integrating a device service producer; (b) integrating a device service consumer (see online version for colours)



(a)



(b)

5.2 MVC Platform extension

Having described our existing MVC Platform, the questions remains: what needs to be extended to support our elderly healthcare scenarios? A list of high-level requirements related to the MVC platform is distilled to answer this question. Discussing all requirements is beyond the scope of this article; but an important subset is listed below. They form a basic set of requirements for extension of our MVC. We discuss aspects of telemedicine, socialisation, management and external services.

Telemedicine

- *Support for remote monitoring and feedback service*: though the MVC platform already has support for remote monitoring of physiological signals, it should also allow authorised parties (i.e., actors or agents) to give feedback to the monitored subject, e.g., in the case of exercises, via the platform;
- *Presentation and storage of these data*: the monitored data should be accessible to authorised persons, both synchronously and asynchronously.
- *Availability of user-specific services*: The MVC platform must allow for interaction with user-specific services, such as physical exercise and medication dispense services. These services potentially differ from user to user and are therefore called user-specific. For integration and usability purposes, their interface should be available to the user via the platform.

Socialisation

- *Tailorable reminders*: the MVC allows for reminders about medical or social events. The reminders are issued based on context information and personal preferences.

Management

- *Content management function*: the care organisation must be able to perform general and content-related management functions in the MVC; such as adding and editing agenda items, announcements of events, and media content related to occurred events. Also, the MVC must allows for delegations, such as accepting or requesting trust connections between people or services on behalf of a user. For instance, an (informal) caregiver can be authorised to make a connection between two clients or to evoke a user-specific service on a clients' behalf, such as the operation of a medication dispenser.

Though we can build on the existing platform earlier described, we need to describe how the abovementioned extensions relate to the existing platform. The remote monitoring and feedback service is already supported by means of the mobile services layer. Feedback however should be given to either the stationary user or the mobile user. The presentation and storage of this data can be made available to authorised users, but is not yet associated to the community of the user. The context-aware matchmaking service should be used for friend finding purposes. This match-making could be done by clients or by caregivers (conform the scenario in Section 4.2). The MVC platform should be able to communicate with user-specific services. This can be made possible through the adopted integration technology of web services. The reminder service described above, could make use of the content exchange and context information services, to provide reminders on relevant content and to alert on relevant locations. Its implementation should be based on a publisher/subscribe mechanism (Eugster et al., 2003) for scalability and to support flexibility with respect to what is notified for each user. Video communication nowadays is widely available but infrastructure quality and usability are important determinants for success. The content management function needs to be

modified for use by non-technical users. In the next paragraphs, we discuss the extensions we are currently considering in some more detail.

5.2.1 Policies and management

The management function enables administrative management of the MVC platform and the mobile virtual communities; new items can also be posted by moderating members in the community. In order to improve the current facilities, policies are necessary to prescribe the access to different mobile and platform services. These *Policies* are the rules or constraints imposed on either actor roles in the MVC or on the interaction with the services. In terms of the actor roles, there could be specific guidelines about what an actor is allowed and not allowed to do. For example, an informal caregiver cannot see exercise results. Thus, for the interactions between a role and a service, rules could be related to *permission constraints* and *prohibition constraints*. A permission constraint is a prescription that a certain act is allowed to occur. A prohibition constraint is the opposite as it describes an act that must not occur at all. Specifying policies is based on the analysis of scenarios, because policies depend on the purpose and use of the MVC as well as on the roles and services that are present in the MVC.

5.2.2 Telemedicine services

In the context of this research, two services are identified as non-trival to the community platform. The first is integration of vital sign monitoring which is currently foreseen in our platform. The second one is support for medication dispenses and in particular compliance, as retrieved as a need from the interview analysis (see Section 4.1). Actors involved in this process are clients, caregivers and (indirectly) pharmacists and medical specialists. In effect this is a specialised community with a shared goal; the support for effective medication use. An electronic medication dispenser can be used together with a compliance service to infer the client's medication adherence. Since the platform should provide information sharing and management functions to the actors, it becomes useful to use the platform to access such telemedicine services as vital sign monitoring and medication compliance.

5.2.3 User interface

Though not the focus of this paper, the user interfaces of the envisioned platform are recognised as crucial to the success of a VC in the elderly healthcare domain. In van 't Klooster et al. (2010) some of the interfaces for policies and management are discussed. These interfaces are intended for caregivers and platform administrators. Currently, we are conducting end-user tests with elderly themselves to select appropriate interfaces for the discussed functionalities and for testing the usability of the system (i.e., usability tests). This results in design constraints and indicators for the availability of usage assistance to end-users.

In sum, we conclude that our telemedicine-enabled MVC platform has the necessary starting characteristics to provide a platform for a functional elderly healthcare community that supports the requirements as elicited. In this section, we have focused on the technical and architectural aspects of the current MVC platform and its extension.

6 Conclusions and future work

In this paper, we proposed a VC for elderly healthcare to exploit the health and socialisation benefits of a community in the elderly care sector. Our contribution is this regard is threefold. Firstly, we showed how a systematic user-based requirements elicitation was conducted for ICT development in elderly healthcare. Our method uses the ICF health model, breakdown analysis, in-depth interviews with end-users, a stakeholder workshop, consortium prioritisation of functionalities, and scenario-based user needs analysis.

Secondly, we showed a services-based VC perspective throughout this paper to support health and socialisation related needs in elderly healthcare.

Thirdly, we demonstrated that it is feasible to enrich our existing MVC platform to support the specific requirements elicited in this work. This is achievable by augmenting the existing platform with additional services, including remote monitoring, socialisation, management and user-specific services. Further developments however require additional user validation to develop the MVC platform successfully.

We are currently working on the implementation of the proposed platform. All the interviewees responded that they are available for this future trial, giving us an appropriate test group size for the technical validation of the platform and for usability tests (Nielsen and Landauer, 1993). We will validate our MVC Platform in a trial with elderly and health professionals. An end-user trial is therefore planned to take place at our testbed in Parc Hoogveld, Sittard, The Netherlands.

Acknowledgements

This work is part of the IOP GenCom U-Care project (http://ucare.ewi.utwente.nl), sponsored by the Dutch Ministry of Economic Affairs under contract IGC0816.

References

Alexander, I.F. and Maiden, N. (2004) *Scenarios, Stories, Use Cases Through the Systems Development Life-Cycle*, John Wiley and Sons, Chichester, UK.

Berg, M. (1999) 'Patient care information systems and healthcare work: a sociotechnical approach', *International Journal of Medical Informatics*, August, Vol. 55, No. 2, pp.87–101.

Broens, T., Huis in 't Veld, R., Vollenbroek-Hutten, M., Hermens, H., van Halteren, A. and Nieuwenhuis, B. (2007) 'Determinants for successful telemedicine implementations – a literature study', *Journal for Telemedicine and Telecare*, Vol. 13, No. 6, pp.303–309.

Camarinha-Matos, L.M. and Afsarmanesh, H. (2002) 'Design of a virtual community infrastructure for elderly care', *PRO-VE'02 – 3rd IFIP Working Conference on Infrastructures for Virtual Enterprises*, 1–3 May 2002, #47d, Sesimbra, Portugal,.

Cooper, A. (2004) *The Inmates are Running the Asylum – Why High-Tech Products Drive Us Crazy and How to Restore the Sanity*, Sams Publishing, Indianapolis, USA.

Corbin, J. and Strauss, A.L. (1990) 'Grounded theory research: procedures, canons, and evaluative criteria', *Qualitative Sociology*, Vol. 13, No. 1, pp.3–21.

Demiris, G. (2006) 'The diffusion of virtual communities in healthcare: concepts and challenges', *Patient Education and Counseling*, Vol. 62, No. 2, pp.178–188.

El Morr, C. and Kawash, J. (2007) 'Mobile virtual communities research: a synthesis of current trends and a look at future perspectives', *International Journal of Web Based Communities*, Vol. 3, No. 4, pp.386–403.

Eugster, P.T., Felber, P.A., Guerraoui, R. and Kermarrec, A. (2003) 'The many faces of publish/subscribe', *ACM Computing Surveys*, June, Vol. 35, No. 2, pp.114–131.

Eysenbach, G. (2001) 'What is e-health?', *Journal of Medical Internet Research*, 20 June, Vol. 18, No. 3, p.2.

Eysenbach, G., Powell, J., Englesakis, M., Rizo, C. and Stern, A. (2004) Health related virtual communities and electronic support groups: systematic review of the effects of online peer to peer interactions', *British Medical Journal*, Vol. 328, No. 7449, p.1166.

Furlong, M.S. (1989) 'An electronic community for older adults: the SeniorNet network', *Journal of Communication*, Vol. 39, No. 3, pp.145–153.

Glaser, B.G. and Strauss, A.L. (1967) *The Discovery of Grounded Theory: Strategies for Qualitative Research*, Aldine, Chicago.

Hettinga, M. (2002) *Understanding Evolutionary Use of Groupware*, pp.28–29, PhD thesis, Telematica Instituut Fundamental Research Series no. 007.

Hsia, P., Samuel, J., Gao, J., Kung, D., Toyoshima, Y. and Chen, C. (1994) 'Formal approach to scenario analysis', *IEEE Software*, March, Vol. 11, No. 2, pp.33–41.

Jini (2009) *Jini Specifications and Archive*, available at http://java.sun.com/products/jini/ (accessed on 28 August 2009).

JiniSA (2009) *Jini Surrogate Architecture Specification v1.0*, available at https://surrogate.dev.java.net/specs.html (accessed on 28 August 2009).

Maloney-Krichmar, D. and Preece, J. (2005) 'A multilevel analysis of sociability, usability, and community dynamics in an online health community', *ACM Transactions on Computer-Human Interaction*, Vol. 12, No. 2, pp.201–232.

Nielsen, J. and Landauer, T.K. (1993) 'A mathematical model of the finding of usability problems', *Proceedings of ACM INTERCHI'93 Conference*, 24–29 April, pp.206–213, Amsterdam, The Netherlands.

Papazoglou, M.P. and Georgakopoulos, D. (2003) 'Service-oriented computing', *Communications of the ACM*, Vol. 46, No. 10, pp.25–28.

Pawar, P., Subercaze, J., Maret, P., van Beijnum, B.J. and Konstantas, D. (2008) 'Towards business model and technical platform for the service oriented context-aware mobile virtual communities', *IEEE 13th Symposium on Computers and Communications (ISCC'08)*, Marrakech, Morocco.

Pruitt, J. and Grudin, J. (2003) 'Personas: practice and theory', *Proceedings of the 2003 Conference on Designing for User Experiences*, pp.1–15 ACM, New York.

Rheingold, H. (1993) 'The virtual community: homesteading on the electronic frontier', Addison-Wesley Pub, Reading, Mass.

Robertson, S. (2004) 'Scenarios in requirements discovery', in Alexander, I.F. and Maiden, N. (Eds.): *Scenarios, Stories, Use Cases: Through the Systems Development Life Cycle*, pp.39–59, Wiley, Chichester, United Kingdom.

Seniorenweb (2009) Available at http://www.seniorenweb.nl (accessed on 28 August 2009).

Stucki, A., Stoll, T., Cieza, A., Weigl, M., Giardini, A., Wever, D., Kostanjsek, N. and Stucki, G. (2004) 'ICF core sets for obstructive pulmonary diseases', *Journal of Rehabilitation Medicine*, Vol. 36, No. 4, pp.1651–2081, *Supplement*, Vol. 44, pp.114–120.

Sutcliffe, A. (2003) 'Scenario-based requirements engineering', *Proc. 11 International IEEE Requirements Engineering Conference*, pp.320–329.

van 't Klooster, J.W., Pawar, P., van Beijnum, B.J.F., Dulawan, C. and Hermens, H.J. (2010) 'Perspectives on the viable mobile virtual community for telemedicine', *Encyclopedia of E-Business Development and Management*, IGI Publishing, (accepted).

van Beijnum, B.J.F., Pawar, P., Dulawan, C. and Hermens, H. (2009) 'Mobile virtual communities for telemedicine: research challenges and opportunities', *International Journal of Computer Science & Applications*, Vol. 6, No. 2, pp.38–49.

van Halteren, A. and Pawar, P. (2006) 'Mobile service platform: a middleware for nomadic mobile service provisioning', *2nd IEEE International Conference On Wireless and Mobile Computing, Networking and Communications (WiMob 2006)*, June, Montreal, Canada.

van Uden-Kraan, C.F. and Drossaert, C.H.C. et al. (2008) 'Self-reported differences in empowerment between lurkers and posters in online patient support groups', *Journal of Medical Internet Research*, Vol. 10, p.e18.

Wellman, B., Salaff, J., Dimitrova, D., Garton, L., Gulia, M. and Haythornthwaite, C. (1996) 'Computer networks as social networks: collaborative work, telework, and virtual community', *Annual Review of Sociology*, Vol. 22, pp.213–238.

WHO (2001) 'ICF: International classification of functioning, disability and health', World Health Organization Geneva, Switzerland.

WHO (2004) 'ICD: International statistical classification of diseases', 10th revision, Geneva, Switzerland.

Notes

1 This centre encompasses 88 single and 6 double apartments with 24/7 care, 64 service apartments, 124 'aging-proof' apartments as well as, e.g., catering, religious, shopping, relaxation and park facilities. Besides, there are 48 nursing home places mainly for dementia patients but they are not in the target group of this study.

2 Quotes have been translated from the original interview transcripts in Dutch.