Open Source Home Care Technology

Technical design and development, user research, cost-benefit analysis, and business modeling

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***Abstract*—This paper presents the work in progress for the Hightech@home project. The aim of this project is to develop technology and knowledge concerning open source home care technology, utilizing open standards. Currently, there is limited availability of high tech sensor and communication technology while costs are high. By producing open source technology we aim at providing a starting point towards interoperability. Hence, increasing availability and lowering costs by avoiding vendor lock-ins. The Hightech@home project consists of five tracks. The first track, the technical design and development, focuses on a portal being generically available through any web browser. The portal will facilitate video contact and transmit and receive data from sensors located in the house, or on the body of the user. Technical design and development is iteratively informed by the user research in the second track. The iterative cycles start with small scale experiments with mock-ups leading to a field study when robust prototypes are available. During this field study, data will also be retrieved to perform a cost-benefit analysis, the third track of the project. To ensure the structural embedding, viable business models are developed in a fourth track. Finally, a fifth track focuses on the facilitation of bachelor students in the Hightech@home project in particular and in eHealth research in general.**

Keywords-home care technology; open source; WebRTC; sensortechnology; user research.

I. INTRODUCTION

The aim of the Hightech@home project is to develop technology and knowledge concerning open source home care technology, utilizing open standards. The choice for open source is based on the current lack of low-cost, high quality, high tech, plug and play home care technology. The choice for open protocols enables interoperability: which most literally unlocks the consumer technology we already have in our homes and which we already carry around.

As far as high tech sensor and communication technology is available for home care, the costs are high. Potential users with the greatest need for this type of technology, e.g. elderly, chronically ill, often lack the required financial means. Vendor lock-in (mostly through the use of closed protocols) is one of the reasons for the high pricing. Customers are dependent on one vendor after an initial choice for home care technology. When there is, for instance, a wish for extending the current technology with additional sensors customers appear to be dependent on the original vendor. Hence, low-cost alternatives are not an option. Although completing a single project will not break through an established vendor lock-in, we aim at producing open source technology and knowledge, thus providing a starting point towards interoperability.

Existing home care technology often requires a technician to install. This not only results in extra costs, but also raises the threshold for people to start using it. Our aim is to design and develop plug and play technology by means of a co-creation process with potential end-users. This co-creation process ensures that customers (clients or patients), informal carers, and carers are able to install the equipment. Furthermore, having interoperability at the centre of development, allows for (re-)use of already existing technology and therefore enable specific use cases which are otherwise not possible or viable.

Designing and developing open standards and open source technology in a co-creation process with potential end-users will not be the only focus of the Hightech@home project. A main research theme of the research group IT (Information Technology) Innovations in Health Care at Windesheim University of Applied Sciences, is the structural embedding of innovations in routine care. The end of an innovative project should not imply the end of the innovation. Too often this is still the case [1]. Initiating the development of a viable business model in an early stage of the project enhances the chance on structural embedding the innovation. The Hightech@home project aims to include this business modelling, also adding a cost-benefit analysis.

In this paper we describe the approach of the five tracks of the Hightech@home project, followed by the preliminary results in the next section. We complete the paper with a conclusion and a description of future work.

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II. APPROACH

The project is structured around four research topics and a fifth goal concerning the structural embedding of eHealth research in the education of our students. The approach of all five tracks is briefly outlined in this section.

A. Technical Design and Development

We envision a portal, to be used at home bringing communication capabilities centred around health-communication. The portal is a framework which can be used to offer different, in general communication, capabilities to the user. The portal should be available through any generic web browser and should be capable of transmitting and receiving video, audio and data streams. The video and audio data streams allow the users to make video calls to other users, whereas the data stream can be used to communicate data from sensors in the house, or on the body. The information gathered from sensors, possibly coupled with the audio and video information can be used by healthcare professionals to remotely assist the user. To realise the above, the design and development consists of fourth tracks.

In the first track we aim to embed open standards based and license free video communications in an open source portal already being developed and partially made available by TriVici Foundation for the community (see [2] – in Dutch). The video communication added to this portal is based on WebRTC (Web Real-Time Communications) [3] and WebSockets for signalling.

Secondly, we will develop and implement secure transfer of sensor signalling and data over WebRTC, with the goal to enable easy and reliable connections using open standards / protocols based sensor technology that is currently available in the (consumer – prosumer) marketplace. This will give meaning to the overall goal of interoperability.

The third track is to interface with the currently under development Smart Optical Sensor and to implement WebRTC and VP8/VP9 to its capabilities. For more information, please see [4].

The fourth track is utilizing newly developed single chip radar technology as a sensory device. This technology is still in its early development phases, and we have yet to determine the goals of this part of the project.

B. User Research

User research is iteratively integrated in the design and development process, leading to a co-creation process. User research starts with the inventory of user requirements and contextual conditions. During early stages of design we use mock-ups in interviews and focus groups. When first prototypes are available potential users will experiment with them in our Telecare Skillslab.

During these interviews and experiments the focus is not only on the technology, but additionally also on important issues such as privacy, legislation, and embedding the technology in daily routines.

When a robust prototype is available, a field study will be carried out. Such a study is the final test for functionality, reliability and usability. Furthermore, during the field study it is explored whether end-users intend to keep using the technology and to what price. A final aim of the field study is to investigate whether the use of the technology leads to the intended effects: more indepency in living at home leading to the same or higher quality of care against lower costs.

The facilities to perform relevant user research have recently been extended. The research group IT Innovations in Health Care established the Telecare Skillslab, not only to contribute to education in eHealth, but also to facilitate telecare research. The Skillslab actually consists of two locations both situated at the campus of Windesheim, separated about 200 m. One of the locations has been furnished as a living accommodation which makes it possible to experiment with domestic applications of sensors in a realistic manner. The other location typically aims at facilitating formal or informal carers, providing care at a distance. Camera's installed in the ceiling provide the researchers with possibilities for non-obtrusive observation. In addition to this interviews and focus groups can be hosted in an informal setting in the living room part of the Skillslab.

C. Cost-benefit Analysis

To ensure the structural embedding of the developed technology in routine care, costs and benefits need to be balanced. Not only should overall costs be evened out with overall benefits, but balance between costs and benefits of single stakeholders within the care chain should also be pursued.

The goal of the cost-benefit analysis in the Hightech@home project is to provide insight in the costs and benefits on the level of single stakeholders within the involved care chain. Relevant data will be collected during the field study.

D. Business Modeling

IT-related business model innovations have become key factors in achieving structural innovation in healthcare [5]. Hence, in former projects [6] we developed a business model approach to be used as an instrument to bridge the gap of innovative eHealth ideas to successful IT-based care services. A main component of this approach is the online webtool, the *eHealth innovation Matrix* ([7] – in Dutch).

When using open source technology, new business models need to be developed. Therefore we will use this eHix-approach during the Hightech@home project. This implies the application of relevant instruments and knowledge as included in all five distinguished phases of the eHix. See Figure 1 for the five phases and examples of knowledge and instruments per phase.

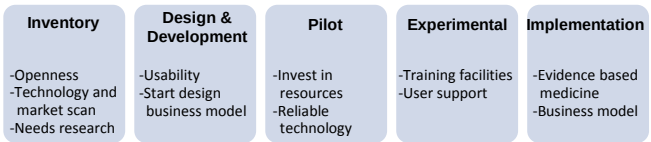

Figure 1. eHix: innovation phases and examples

E. eHealth research in education

Being a University of Applied Sciences, it is important to include students in our research. In this project bachelor Information Technology students are involved both in technical design and development as in the above mentioned research. User research is also performed by Bachelor Health and Welfare students.

To facilitate future involvement of students in our eHealth-projects, an additional aim of the Hightech@home project is the design and development of a digital learning environment. This environment will facilitate students with easy access to all relevant knowledge to provide them with a head start.

III. PRELIMINARY RESULTS

The project Hightech@home started in June 2013 and will conclude at the end of 2014. Hence, at the time of writing the first four months of the project can be considered. This section highlights some preliminary results and lessons learnt from these four months.

A. Technical Design and Development

The portal contains video and audio capabilities to communicate with care professionals and friends. Since the portal itself is made available through the web browser, the video and audio capabilities should also be available there. The benefit of this set-up is that no additional software is required. We use WebRTC [8] to facilitate video and audio in the browser. At this moment WebRTC is available in at least Google Chrome, but implementations in other browsers are likely to be completed in the future. WebRTC makes it possible to communicate peer-to-peer , without the need for a central server. Currently, in our set-up we assume both clients to use the same codec, which makes a translation of the data stream unnecessary. The result is a fully peer-to-peer audio and video connection between two clients.

Setting up this connection between peers, however, requires some administration. We used the Session Initiation Protocol (SIP), with a central Asterisk server for this purpose. After initiation, the connection is completely peer-to-peer and the central server is no longer needed.

B. User Research

Top priority of the involved user researchers, is the selection and inclusion of a specific end-user target group. So far we were not successful in obtaining full commitment of a care organisation, despite principles concerning the involvement of end-users. This puts pressure on the intended co-creation process. Due to political developments in The Netherlands, care organisations need their full attention, available time and staff to focus on their primary processes. Innovation activities are cut back. Hence, involvement in a project like Hightech@home becomes less likely. At the moment of writing we are still aiming at the commitment of a care organisation. Furthermore we are considering alternative options concerning informal carers.

C. Cost-benefit Analysis

To provide insight in the costs and benefits on the level of single stakeholders within the involved care chain, a cost-benefit analysis will be drafted in the Hightech@home project. The relevant data for this analysis will be collected during the field study where the prototype will be tested for functionality, reliability and usability. It is only after exploration whether end-users intend to keep using the technology and to what price and whether the use of the technology leads to the intended effects that this cost-benefit analysis can be drawn up.

D. Business Modeling

Menko et al. described the eHealth innovation Matrix and illustrated the application of its business model framework with an example of an eHealth innovation, namely the DiMove service [6]. In the Hightech@home project the eHix will be applied as well. Both the eHix Scan and the Library will be utilized. The Scan consists of a questionnaire which allows users to determine the status of their project. The Library contains, among other things, templates and checklists to facilitate the innovation process.

Not only will the eHix be applied in the Hightech@home project, but the use of the eHix will also be studied in order to discover opportunities for further improvement and enhancement of the approach. Technical action research (TAR) [9, 10] has been selected to study the use of the eHix in practice. In this approach, the researcher plays three logically separate roles: the developer and the investigator of (in this case) the eHix approach together with a role in which the client is supported in using the eHix to improve the client's eHealth innovation process. In these three roles the eHix will be applied, studied in practice, and possibly improved.

E. eHealth research in education

The project activities of the project Hightech@home are carried out by researchers, lecturers and students from both the programs Bachelor of IT and Bachelor of Health Care. This creates integration of education and research and a multidisciplinary approach. The activities in the various Hightech@home projects should provide a structural assurance in the educational curriculum of IT training. Therefore, after careful consideration of the various forms of imbedding the Hightech@home project activities in the educational curriculum at the start of the project, one of the deliverables of this project is a sustainable learning environment for IT students in the field of e-health and home care technology. Compatible with the current trend in education, this deliverable will take form in a digital learning environment (DLE) created by and for Bachelor of IT students.

The DLE consists of three levels - macro, meso and micro level. The macro level gives the context of e-health and the documentation contains general introductions to e-health in the IT domain. The micro level consists of information on home care technology in the Netherlands. At

the micro level all documents regarding the Hightech@home project are presented.

The DLE has many benefits. It ensures that students of Information Technology (IT) have access to a high quality of information related to e-health and open high-tech home technology in a quick and in a pleasant way. Using open technology of d-wiki, the DLE is easy to access and has as low cost start up and maintenance [11]. Through independent study of this learning environment the IT student can quickly prepare and act in any e-health project and an open home care technology project almost independently, with less preparation time and little guidance.

After in-depth interviews with various groups of IT students, consultation with researchers and lecturers and after thorough desk research on digital learning, two IT students have drafted the requirements analysis and set up the technical structure of the DLE. The next two months these students will sample the content and present the documentation on the DLE in the appropriate way. In January 2014 the first version of the DLE will be released after formal approval by the project group. Ready for use this DLE will be evaluated and updated methodologically by the next group of IT students working on the Hightech@home project.

IV. CONCLUSION AND FUTURE WORK

In this paper we described the Hightech@home project's ambition to develop technology and knowledge concerning open source home care technology utilizing open standards, to perform user research with prototypes, to draft a cost-benefit analysis, and to develop a viable business model. We also presented the first months of progress of the Hightech@home project.

The main conclusion to be drawn from the current progress is that WebRTC seems both very promising to realise our ambitions and feasible to work with. With guidance from our researchers, the students were able to realise a fully peer-to-peer audio and video connection between two clients.

A second conclusion concerns the high ambitions of the project. For a project lasting only 18 months with limited resources we are quite demanding with our goals set on five different topics: Technical Design and Development, User Research, Cost-benefit Analysis, Business Modelling, and eHealth research in education. Nonetheless we think we can realise our ambitions and hence make a difference in home care by providing low cost plug and play home care technology.

Future work on the project concerns the plans on all five tracks as described, with a high priority focus on including a care organisation in the project team. Beyond the described plans, future work concerns scaling up the project. Several eHealth companies have already shown interest in joining the team if a follow-up project will be funded and started. We conclude from this interest, that open source home care technology is a wanted technology to further develop and investigate.

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REFERENCES

[1] Broens, T.H.F., et al., *Determinants of successful telemedicine implementations: a literature study*. Journal of Telemedicine and Telecare, 2007(13): p. 303-309.

[2] OpenPortaal. [27-01-2014]; Available from: www.openportaal.nl.

[3] WebRTC. [27-1-2014]; Available from: http://www.webrtc.org/.

[4] OpenXS. [27-1-2014]; Available from: www.openxs.eu.

[5] Haaker, T., *Business modellen voor ICT-intensieve zorginnovatie.*, 2010, Nictiz Kennisartikel 10025.

[6] Menko, R., et al., *Applying the Stof Business Model Framework in eHealth Innovations*, in *eTELEMED 2013: The Fifth International Conference on eHealth, Telemedicine, and Social Medicine*2013: Nice, France.

[7] eHix. [27-1-2014]; Available from: www.eHix.nl

[8] Johnston, A.B. and D.C. Burnett, *WebRTC – APIs and RTCWEB Protocols of the HTML5 Real-Time Web*2012: Digital Codex LLC.

[9] Wieringa, R.J. and A. Morali, *Technical Action Research as a Validation Method in Information Systems Design Science.*, in *Seventh International Conference on Design Science Research in Information Systems and Technology (DESRIST). LNCS 7286.*, K. Peffers, M. Rothenberger, and B. Kuechler, Editors. 2012, Springer. p. 220-238.

[10] Wieringa, R.J., *Designing technical action research and generalizing from real-world cases.*, in *24th International Conference on Advanced Information Systems Engineering, CAiSE*2012: Gdansk, Poland.

[11] DokuWiki. [27-1-2014]; Available from: https://www.dokuwiki.org/dokuwiki.

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