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# Learning from an Ambient Assisted Living Lab: the case of the Intelligent Bed

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**Abstract.** This paper presents methodological lessons learned from an Ambient Assisted Living (AAL) lab exploring the use of intelligent beds in a nursing home. The living lab study was conducted over a period of three month. 20 intelligent beds were installed. Data was collected via self-registration, diaries, observations, interviews and workshops with residents, nurses, nursing assistants, management, building officers, and purchasers from the Municipality. The paper presents an analysis within the overall themes of technology, use, and care, which is discussed by use of the SWOT framework presenting strengths, weaknesses, opportunities, and threats identified in the living lab of the intelligent bed. The paper concludes by emphasizing the need for mature technology, long-term studies, clarification of role and tasks of different stakeholders, and attention on methods used for living lab evaluations.

**Keywords.** Living Labs, Ambient Assisted Living, Intelligent bed, SWOT analysis.

## Introduction

This paper presents methodological lessons learned from an Ambient Assisted Living Lab exploring the use of intelligent beds in a nursing home. Ambient Assisted Living (AAL) is defined as "services based on informatic tools that systematically process data information or knowledge about the state of health of elderly people in their natural environment, aiming to preserve or enhance their state of health or to reduce the negative consequences of a disease" [1]. The ambition to design technology that interacts closely with the use environment is depending on innovations carried out in co-operations with users in order to understand and develop the complex practice of AAL. A living laboratory is an ideal approach to support such co-operative technology innovation in real life environments.

Living labs are technological installations in (semi)-naturalistic settings with the objective to conduct medium- or long-term technological studies and innovations in co-operation with users "living" in the environment. Living labs are "semi" naturalistic in the sense that they are set up in real life "living" environments like cities [2] [3] or as in this case in a nursing home. These environments are turned into "labs" by the installation of new technology that will possibly affect the everyday life of people living in the "lab". In this case the intelligent bed affects health care professionals' and residents. Living lab research is occupied with studies of how people react, change, and integrate the new technology into their everyday lives [4]. Data collection often

includes a mix of unobtrusive and obtrusive methods like observations, instructions for users' self-documentation, interviews, and workshops [5]. The medium- and long-term aspect distinguish living labs from usability labs and simulation labs [6] which have been proven successful for quick findings of many usability issues but often miss aspects related to in-situ use of the technology [7] [8]. Innovation is the primary ambition of living labs [5], [9], [10] and user participation integrated in technology innovation distinguish living labs from merely technological tests. Though some living labs are presented as "test beds" they do emphasize that "benefits or usefulness for people in everyday life must be proven before technology or services can be said to be a success" [11].

The ambition of this paper is to extract methodological lessons learned from an AAL lab. Recent research has highlighted the complexity of living labs and a need to learn from and develop the living lab methodology [12]. The living lab concept is still novel and "requires substantial research to optimize its operations and methods although already promising" [5]. Experiences from long-term living lab studies are presented as "rewarding, though often inefficient" [13] and as "expensive to run" while "expectations are high as to what they will provide" [4]. Consequently "There needs to be more explication of the benefits and costs" of these "wild" and "living" lab studies [4]. Several methodological concerns related to living labs are found in the literature. These include dilemmas of how artificial to make the naturalistic setting in order to enable the right level of control to conduct evaluation and keeping sense of the real life practice [14]. It is acknowledged, that understanding the "living" practice does not happen *per se* just by setting up technology in a real life setting, which calls for development of catalogues or taxonomies of AAL lab methods. Additionally, there is a call for methods that focus on challenges of keeping users motivated during the lab period [12], facilitating participatory innovations among various interests and stakeholders [5], and the importance of maturing the technical set-up since unpredictable technical problems, device errors and other technical influencing factors are barriers disturbing the "living" aspect of the lab [12].

The research presented in this paper supports the call for methodological explication of living labs with specific emphasis on AAL labs. The work presented is part of a project, LabX that is a platform for public private partnerships on innovation of ambient assisted living technologies. The intelligent bed case, presented in this paper, is the first in a series of living labs working towards methodological models for AAL labs. In this paper we first present the case. Second, methods used in the AAL lab of the intelligent bed are presented. Third, central themes derived from data analysis are presented. The SWOT framework is used to point out and discus the strengths, weaknesses, opportunities and threats identified in the AAL lab of the intelligent bed and the consequences for future AAL lab methods.

## 1. The case of the intelligent bed

The case of the intelligent bed is the first in a series of AAL lab set up in the LabX as co-operative product innovations between technology providers (engineering enterprises, in this case the producer of the intelligent bed), users (in this case a variety of stakeholders including nurses, nurse assistants, residents, nursing home management, and purchasers from the Municipality), and researchers (responsible for coordinating and facilitating the living lab, partnerships, data collection and analysis).

The primary technology of the intelligent bed is sensors in the mattress sending alarms to staff's mobile phones when residents leave the bed, if residents are not in bed for a certain period of time, if the sheet is vet, if the breaks are not turned on properly. Additionally, the bed turn on a light placed under the bed for the purpose of safeguarding the resident's way to e.g. the lavatory. The Nursing home where the living lab was set up has 30 residents living in their own apartment consisting of a combined living- and bedroom and a bathroom. Initially 20 residents agreed to try the new intelligent bed, but three had second thought in the very first days of the living lab period and got their old bed back. Thus 17 beds were actually in use for a period of three months. Seven of the employees were selected as super users. The super users received a thorough introduction to the functionality of the intelligent bed before installation of the beds, given by the company. The intelligent beds were installed and turned off again within the first 24 hours due to technical problems. After a couple of weeks the intelligent bed was re-installed and tested in 3 month during summer 2013.

## 2. Methods

The overall aim of the LabX project is to develop a methodological model for supporting innovation of ambient assistant living technologies. This includes product innovation and practice innovations, respectively. The case of the intelligent bed focused on adjusting the AAL technology and on understanding functionality, workflow and utility issues. Thus, potentials for innovation concerned these matters.

During the test period of the intelligent bed data was collected through a) observations recorded via field notes and video, b) interviews (before and after installation) with employees at the nursing home, management at the nursing home, residents and focus group interview with building officers and management, c) manual registration of types of notifications received from the bed and of amounts of washings of vet sheets, and d) log books made by staff on a regular daily basis. After the test period e) a workshop was conducted facilitated by researchers and with participants representing nurses and nursing assistants, management, building officers, and a purchaser from the Municipality. At the workshop videos from observations in the living lab were presented and discussed.

The analysis in this paper is primarily based on data from the interviews, supported by the manual registration of types of notification received from the bed. In total 18 interviews were conducted. Before the implementation 7 employees were interviewed and 6 of them were interviewed again in the end of the implementation period; two residents were interviewed before and one of them again after; and the manager of the nursing home was interviewed before and after the implementation of the intelligent beds. The overall themes for the interviews were expectations and experiences, respectively. Interviews were audio recorded and transcribed. Data was coded in order to identify core themes from the living lab. During this process three main themes came to light concerned with 1) technology, 2) use, and 3) care issues.

## 3. Lessons learned

*Technology*: The technical implementation of the bed beame a much bigger challenge than expected. Especially in the beginning of the living lab there were problems with a

large amount of alarms from the beds and it was almost impossible to turn them of, the switch off bottom being placed under the bed. Some alarms were send because the breaks were not put on and the staff learned to do an extra push to ensure that brakes were actually on. Also switching off the bed became possible from one of the three remote controls belonging to each bed. The main technical problem, however, was that the alarm systems of the intelligent beds could not be integrated properly with the alarm system already in use at the nursing home.

*Use*: The alarms most valued by the staff were the "out of bed" alarm and the "wet alarm". Several examples of the benefits of these functionalities were mentioned e.g. that the "wet alarm" meant that the pad of some residents could be changed in time before the whole bed got wet and that the "out of bed" alarm ensured that residents did not loose their way in he middle of the night. Furthermore it was noticed during the test that the wet sheet was to small and also perhaps to easy to ruin or wear out, and that the bed itself could not fit into the normal procedure of washing beds.

*Care*: As for the question of what the implementation of the intelligent bed would mean for the care of residents several issues were considered, e.g. that the beds would mean a better (uninterrupted) sleep for the residents, and that the resident perhaps would feel more safe e.g. to visit the bathroom by themselves knowing that if something went wrong the alarm would go. However during the three-month evaluation period issues in understanding the technology in itself played a dominating role and issues in use and care remained on a more speculative level.

In order to contribute to methodological development of AAL labs and inspired by related living lab evaluations [15] we discuss these lessons learned in terms of the SWOT framework to emphasize the identified strengths, weaknesses, opportunities, and threats observed during the study.

*Strengths*: The nursing home living lab provided a natural setting to explore the complex relation between the intelligent beds, the residents, and the working routines. Although the major problems were due to the integration of different alarm systems the consequences of this were only fully realized when the 17 beds were switched on in the nursing home.

*Weaknesses*: One of the weaknesses of living lab is that it requires lot of resources. In this case it involved 17 beds, the residents, the staff at the nursing home, people from the municipality, the company developing the intelligent beds and the researchers. To identify the roles and task of all these people involved and to manage the project is a big challenge.

*Opportunities*: An obvious opportunity in living lab is to activate users innovative thinking on both uses and value of technology for care. I our case this innovative potential was not realized due to problems with the technology.

*Threats*: The immaturity and fragility of the technology combined with limited time frame makes it difficult to provide room for co-operative innovation processes.

In conclusion the living lab of the intelligent beds add to existing living lab literature in emphasize the importance of mature technology, long-term studies and clear roles for involved stakeholders.

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