Board Games and Regulars' Tables — Extending User Centred Design in the Mobia Project

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Abstract. To allow persons with mobility issues to remain mobile, the three-year project Mobia set out to develop a technology-supported human-based service within public transport: mobility guides provide a helping hand for passengers with mobility issues. The Mobia system can be positioned within the field of AAL and consists of multiple user interfaces and actors to coordinate and realise the point of service. This paper introduces two extension to the User-Centred Design methodology which were successfully applied during the course of the project. The first is the development of a large board game like demonstrator that allows for simulation of realistic scenarios within the scenario during which observation of user behaviour can take place. The second – regulars' table – is a monthly face2face meeting between developers, passengers and mobility guides serving as a platform for exchanging experiences, testing and discussing new ideas. Results from the Mobia project are discussed.

Keywords: User-centred design · AAL · Board game · Public transport

1 Introduction

Within two recent German funding schemes by the Federal Ministry for Economic Affairs and Energy (BMWi) *Door to Door* (Tür zu Tür) and Federal Ministry of Education and Research (BMBF) *Mobile up until high ages* (Mobil bis ins hohe Alter), about 25 projects set out to address mobility issues within the scope of Ambient Assisted Living (AAL). The officially demanded objectives were to develop integral concepts for elderly persons by combining various public transport systems into intermodal transport systems and beyond that include human based services to develop holistic transportation concepts. The projects additionally focussed on a number of adjacent topics like indoor and/or outdoor navigation or social community aspects [1]. Although a majority opted for bringing innovative concepts somehow close to the market, few, if any, really succeeded in doing so. Indeed, some of the projects were rather basic research

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oriented projects and in the case of other projects, crossing the *valley of death*[1] would had required more investment which is not always granted. Bearing all this in mind, still a relatively low success rate in bringing the project results into the market can be observed.

One conducive approach in analysing this phenomena is to take a closer look at the research methodology used. The mobility projects are basically AAL projects and thus geared towards the users' needs. Within the last 40 years several methodological approaches have been evolving ensuring that development meets the users needs. One of them is user-centred design (UCD) [5,8] which has been deployed by mobility projects like SIMBA, SenioMobil, Dynamo, Campagno or Mobia [1,2]. Although applying UCD in the case of mobility projects seems both straight forward and well backed by research, there is a great number of interpretations how UCD should be actually implemented [9]. This very fact leads to a big degree of freedom in applying this methodology, potentially overseeing some major challenges arising especially when it comes to adapting UCD [15]. In the case of the afore mentioned AAL mobility projects systems are meant to comprise multiple *actors* and *artefacts* [18] – a user interface is only one artefact of multiple – suggesting different approaches like socio technical design (STD) [19]. STD advocates for the direct participation of the end-user in the design process and is therefore closer related to so called participatory design (PD) approaches which were deployed in mobility projects like PASSAge or S-Mobil 100 [1,3]. But especially in PD, it can be difficult for end-users to participate in innovative solutions given their special needs [15]. Juxtaposing UCD STD and PD there is a large conceptual overlap in the sense of putting the users' needs at the center of the development including generic challenges within this area which this paper is going to discuss from a UCD perspective.

Below, two main challenges are briefly discussed in order to pave the way for a detailed description of how they could be tackled. Within the mobility projects, developing new intermodal transport systems and possibly augmenting them with an additional service concept multidisciplinary teams have to overcome two major challenges:

1. Enabling the user an easy **comprehension** of the innovative system as a whole.
2. **Maintaining** the iterative manner of the chosen methodology and thereby being accompanied by the users throughout the whole project's lifetime and beyond.

Enabling an Easy Comprehension. UCD amongst the other outlined methodologies typically starts with a comprehensive and careful analysis of the users' needs. Derived from this analysis, functional as well as technical requirements are worked out [14] which are then often incorporated by *personas* and

[1] Especially in Europe there is a gap between development of science and development of commercial products – the so called valley of death – which results in large problems with knowledge exploitation [4].

scenarios [17]. In a second step the requirements are implemented into user-test ready mock-ups or products which are in a third step evaluated by the actually addressed users. Of course there are multiple variations in labelling the steps included in UCD and this is just an abstract description of how UCD methodology is typically applied [5,7]. Still there is always a conceptual break between the theoretical analysis of the users' needs and the practical implementation of innovative solutions which should be evaluated by the user in the adjacent step. In most cases users are not disturbed by this break and perceive a certain usefulness of the novel solution. As the *Technology Acceptance Model* (TAM) predicts, the perceived usefulness and the perceived ease of use are the two key predictors for novel technical solutions to be accepted by the user [13]. Ensuring a perception of usefulness can be very challenging in technologically novel systems though. This might be due to the reason that targeted users are either restrained by own mental abilities or – as outlined above intermodal mobility concepts build upon multi-artefacts and multi-actor architectures – proposed new systems are to difficult to understand with reasonable effort [15]. Additionally, the challenge may arise from the fact that UCD was initially developed within the community of user interface designers [16] and therefore "traditional user-centred design methods provide little guidance in how to involve the elderly in [...] ambient assisted living scenarios" [10, p. 334].

Maintaining the Iterative Shape. There is a certain risk that a UCD cycle stays a one-time activity, which is performed at the beginning of the project and gets cut out approaching the final project phase typically running on a tight schedule [7]. This is by definition poor UCD, as UCD methodology builds upon an iterative procedure which should be maintained throughout the project's whole lifetime.

To conclude, having mentioned that development methodologies focusing on users' needs are very popular upon AAL applied research, but still a highly flexible methodology, two frequently overlooked challenges are connected to user acceptance and **comprehension** of novel intermodal concepts and **maintaining** an iterative approach throughout the whole development. The scope of this paper is to suggest extensions to UCD methodology and to provide implementation insights from the Mobia project – one of the afore named mobility projects – which addressed the above mentioned challenges early on. To conclude this paper will discuss the implemented method's efficacy.

2 Mobia

The research project Mobia aimed at reducing barriers within public transport in central Saarbrücken[2] by developing and validating a technology-supported human-based service system. Mobia augments public transport internal physical means (e.g. existing accessibility features in means of transport like fold out

[2] Saarbrücken is the capital of the German state Saarland: 180.000 habitants.

wheelchair ramps) and internal digital means (e.g. interface for accessing time tables) by a public transport comprehensive mean: *mobility guides* (German: Mobilitäts-Lotsen) providing a service chain by helping passengers from door to door, or at particular points or even during sub-parts of the journey during which the passenger – of some reason – needs help. This includes for example entering the bus at a particular bus stop (because the bus and bus stop do not match), changing from bus to tram (because the way is too long), walk from the tram to the entrance of the passenger's doctor (because the passenger is afraid of getting lost) or helping a young father with a child, buggy and shopping bags to enter the bus (because he cannot handle that many things at the same time). The technology consists of a software for intelligent disposition and coordination of the mobility guides and front-ends for pilots and passengers. The coordination software directs the mobility guides to the requested point of service. The passenger front-end needed to be implemented flexibly so that all passengers can interact with it. In addition to telephone calls, personalised and adaptable user interfaces running on smartphones that allow their users not only to order trips, but to receive real-time support during the trip were envisioned. This includes tracking service as well as notifications and alerts. The Mobia system was hypothesised to be capable of delivering coordinate personalised interaction and service that allow – in principle – everyone to utilise public transport.

3 Methodology

There are two common challenges using UCD within the domain of AAL mobility projects, which are connected to user acceptance and **comprehension** of novel intermodal concepts and **maintaining** an iterative UCD approach throughout the whole project's lifecycle. This paper claims that noticing these challenges and addressing them upfront can help to increase the probability of succeeding in bringing the envisioned solution close to market. Therefore this paper introduces two methodological extensions to UCD and provides evidence for their effectiveness from Mobia project.

The Mobia project included two traditional iterations of UCD development, an extended iteration including a fully working simulation of the system and a one year lasting longitudinal field test which included monthly feedback iterations. The two first comprehensive UCD iterations were following the widely recognised UCD methodology and included a paper prototype evaluation of first interfaces and a mock-up version of the user interface on a smartphone (see Fig. 1). After these two iterations plenty of feedback concerning the user interface was collected but the overarching Mobia system implementing the service concept was still unreviewed by the user group.

Considering this, one could expect that potential users would be overstrained and have concerns when testing the whole system in a real field test. This issue is of great importance, as the requirement phase at the beginning of the UCD

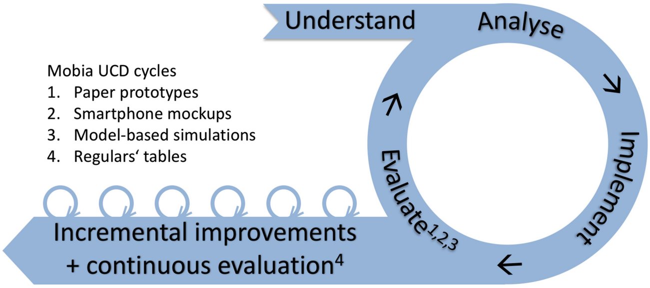

Fig. 1. User centred design as used in the Mobia project including two cycles of mock-ups based evaluation, the demonstration board workshops and the project's 12 month lasting field test.

revealed that many users avoid using public transport due to its confusing complexity; this is of course a subjective statement and sometimes related to limitations on the user side. Therefore the project included a third UCD cycle whose evaluation phase was geared towards evaluating the Mobia system as a whole and which dealt with the challenge of making complex systems understandable.

Easy Comprehension Through Board Game Based Simulation. The Mobia system includes multiple actors, as well as multiple artefacts including different interfaces and technological components To ensure a certain feasibility of evaluations breaking the system's concept down to simple easy to grasp benefits for the user is nevertheless of vital importance. This becomes especially articulated within the domain of AAL, as users often bring in plenty of different needs due to age or disease related decline in senses or cognitive abilities [22]. Especially cognitive impairments make it very challenging to run an evaluation of a complex system within AAL [18]. Tackling this issue the Mobia project drew upon rich insights from former projects [6] and existing research [11] successfully using simulators in the context of AAL for development of user interfaces as well as for demonstration purposes. Therefore it was decided to use a large board game like demonstrator dedicated for user evaluations within the UCD cycle (Fig. 2).

The Mobia demonstration board is composed of an excerpt of the street-map of Saarbrücken, including public transport (busses and trams) stops and tracks, serving as the board on top of which various figurines simulate passengers and mobility guides. Various small 3D-printed vehicles depict busses and trams. To make the model an interactive simulator, both board and vehicles were equipped with sensors: the buses and trams with three magnets; reed switches are mounted in the board under every public transport stop. Combining this information and the number and the arrangement of the magnets under the vehicles enables one to automatically determine which vehicle is at which stop. Therefore, sensor data are fed to an Arduino Mega micro controller which is connected via USB to a PC. This information is then transmitted by a simulation of the actual timetable

Fig. 2. The interactive Mobia demonstration board including tokens for busses, trams, mobility guides and passengers. The board measures 2.1 m times 1.1 m and is equipped with reed sensors tracking the position of the vehicles.

information system of Saarbrücken's public transport to the backend which also coordinates the front-ends of passengers and mobility guides. In this way it is possible to simulate the trip in a virtual time. RFID tags are attached to every stop and vehicle so passengers and guides can sign up with the help of their near-field-communication-ready front-ends at the stops and at the vehicles and thus transmit their position with one touch to the system.

This demonstration board draws upon two major benefits commonly found in the aria of serious board games: Breaking down the complexity of real life systems makes them easier to understand and enabling direct manipulation through tangible objects reduces the barrier and fear for interaction (see also [6]).

Board games can be used to simulate complex real world systems and make them easier to understand via means of abstraction and reduction of cognitive load[3]. In the Mobia project the challenge was to make the complexity of a technology supported service concept building upon public transport of a whole city comprehensible. This concept includes the interaction of different types of trams and busses, different actions with the system, such as registering at stops or booking trips and different roles such as mobility guides and passengers. Right from the beginning it was clear that only by understanding complex interaction of all parts of the system the project could ensure the important perception of usefulness to pave the way for user acceptance of this novel service concept. Building upon scenarios and personas from the requirement phase of the UCD, the aim was to simulate a realistic scenario of a complete Mobia service chain through an abstract easy-to-understand but not oversimplifying model.

Evaluating interaction of touchscreen based interfaces, designers often encounter hesitation and fear by older users. One explanation for this phenomena is the fact that the age related decline in sensitivity to vibration [20] limits the haptic feedback provided by touchscreens and thereby prevents elderly users from a comfortable quality of interaction [23]. This is why another declared aim of the Mobia demo board was to ensure the haptic experience of classic board games taking into account that older users have special needs for haptic interaction.

[3] Board games are effectively used in professional training programs simulating complex scenarios like humanitarian crises https://paxsims.wordpress.com/aftershock/.

In summary, the Mobia demo-board is a model-based simulation of public transport in the style of a classic tangible board game and provides the testing ground for evaluation and acquisition of rich qualitative data within the UCD cycles.

Accompanying the User on His/Her Journey. The Mobia project set out to comprehensively evaluate a running system within the UCD methodology. Therefore it was necessary to build upon a strong basis of users which would regularly use the system and agree to attend recurrent meetings to evaluate and give feedback. For this purpose the Mobia project included a one year lasting field test which was accompanied by evaluative monthly meetings, so called regulars' tables. This approach is promising because of two aspects: The longitudinal evaluation is a perfect indicator for the maturity of a system and the long time period and the personal contact to the user help to set up a project friendly user base which helps to finalise a running prototype.

By the means of a multiple month lasting longitudinal evaluation, projects can prove a certain maturity of a technology based system. Building a prototype and testing it in the real environment within a one year lasting longitudinal study typically represents a *Technology Readiness Level* (TRL) of six or seven [21]. This TRL can be used to rate a system and therefore can serve as indicator of a project's success. A longitudinal study also allows the developers to finalise the system as the main functionality remains fix but the team can focus on smaller features based on the users' feedback.

At regulars' tables on a monthly basis, developers can keep up the personal contact to the user and profit from a well cultivated relationship with an established friendly user base. Especially the fact that there is room for the user to understand the perspective of the developers makes the cooperation more efficient. In addition to that, the physical presence of project members, typically technology experts, can serve as an support structure for technological problems occurring during the field test. This is especially important as most users in AAL contexts are not that tech savvy and therefore need some attention addressing their issues while interacting with the system [12]. Those aspects in combination with the ambient hospitality[4] a regulars' table helps building a strong project friendly user base which can be the basis of efficient cooperation.

Including a longitudinal field evaluation while accompanying the user at regulars' tables combines the benefit of proving a certain technology maturity and also getting constant feedback from a friendly user base which can be fed back into feature adjustment and finalisation of the system.

4 Results and Discussion

Havnig identified two major challenges within UCD for complex AAL mobility systems related to **comprehension** of complex systems and **maintaining**

[4] Within the Mobia project fine torte from one of the high quality local confectioneries was povided.

Table 1. User feedback (subsumed in core topics) acquired during the WSs classified according to *aspect of the system* (horizontal) and *type of feedback* (vertical).

	Public transport	User Interface	Service concept
General	– Delays	– Wording	– Locations of high need
	– Connections	– Technical device's barriers	– Office hours
	– Safety at stops		– Customer support
Interaction	– Drivers' behaviour	– In-app navigation principle	– Service manners
	– Complex ticket machines	– Notifications & Alerts	– Registration at stops
		–Booking process	– Request handling duration
		– Help functions	
Representation	– Stops' bad condition	– Buttons & Icons	– Guides' recognisability
	– Stops' equipment	– Trip representation	– Guides' behaviour in public

the iterative shape of UCD, this paper described two extensions to the UCD methodology which were successfully applied within the project.

Results. Within the third UCD cycle of the Mobia project, in February 2013, there were eight two hours lasting workshops (WS) including the demo board visited by the project internal usability experts and around three target users each time ($\Sigma = 20$) as well as two mobility guides. The acquired feedback can be subsumed and plotted in a three times three matrix with the axis *aspect of the system* (public transport, user interface & service concept) and *type of feedback* (general, interaction & representation), see Table 1.

The one year lasting field test took place from November 2013 until Oktober 2014 and set out with a number of 27 subjects participating which grew up to a total number of 71 subjects having used the service at least once (compare Table 2).

Table 2. Number of users showing up to regulars' tables (RT), total number of users enrolled and at least once active (ΣU), number of users active on a monthly basis (U/M) and number of trips conducted per month.

	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
RT			25	16	19	19	15	16	13		14	23
ΣU	27	33	41	41	45	49	57	62	66	70	71	71
U/M	26	18	28	28	28	29	30	28	34	24	21	17
Trips	40	12	65	65	109	193	139	162	205	67	110	136

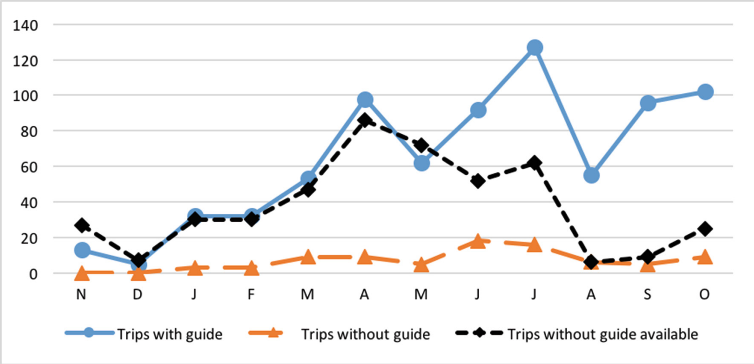

Fig. 3. Trips conducted within the one year field test, lasting from November 2013 (N) until Oktober 2014 (O), with the help of a mobility guide (blue), without the help of a mobility guide but within their working hours (orange) and outside normal working hours (black). (Color figure online)

Plotting the user interactions during the field test clearly shows an increase in total number of trips conducted using the Mobia interface which reached its peak in the summer and then slightly dropped towards the end of the field test (see Table 2). This development aligns with a growing total number of users enrolled into the field test; these are users which conducted at least one trip during the field test. Correcting this total number of users for their monthly activity, shows a relatively constant number of users which were active on a monthly basis.

Further analysis of the number of trips booked reveals that the demand for mobility guidance constantly grew during the whole period, the dip in August is due to holidays. The number of trips not demanding for help of mobility guides varied a lot. Due to the fixed service hours of the Mobia service, there are two cases counting as trip without assistance: trips where mobility guides were available but the user decided not to demand for help and trips outside of service hours but the user decided to conduct the trip anyway. The latter kind of unassisted trips followed the same bell curve as the total number of trips mentioned above, whereas the number of trips refusing available assistance stayed on a low level throughout the whole testing period (see Fig. 3). This bell curve distribution can be interpreted as a season effect as the number of self-conducted trips drops in autumn and winter due to less daylight and worse weather conditions.

Discussion. The demo-board workshops were geared towards improving the core UCD development whereas the regulars' tables were geared towards supporting the longitudinal field test. The former revealed a rich variety of qualitative feedback illustrating how this tool helped the users to quickly understand and to look at the whole system from different angles. This becomes clear through the feedback which did not only cover the user interfaces, but in principle all aspects of public transport and additionally the whole service concept. Therefore, the comprehensive feedback from such quasi-realistic game playing can add value to commonly used techniques. Moreover, letting the user interact with the simulator opened the possibility for the user interface designers to simply observe and not only acquire explicit feedback. This got especially accentuated for elderly users who found it problematic to abstractly reflect on the system which is in one line with the literature and previous findings [6,11,15]. These insights perfectly align with the need for evidence for how to visualise STS [19]. Furthermore, the WS attendees acknowledged the amount of engagement of the project and consortium as made explicit through the *get-together* of the whole project team. Therefore, the WSs helped to propel the development of the system in the midterm and thus legitimated the relatively high monetary and organisational expenses.

The longitudinal study was meant to serve as a realistic benchmark of the system and to help jointly further improving it through dialog and collaboration between all stakeholders. One of the regulars' tables' main advantage was to circumvent users' discouragement which would eventually cause them to leave the project. The regulars' table was open for any passenger which lead to a relatively high fluctuation sometimes threatening the meetings to loose track. Therefore, users were split into small groups discussing similar topics. Especially the technical support for the not very tech-savvy users was of extreme high value and helped keeping a strong *friendly* user base.

The initial tables turned out to become a forum for users' negative experiences and complaints which caused a very unproductive atmosphere, although much of the complaints did not target the project objectives, but the public transport as provided. To tackle this, the project introduced a *passenger's diary* where the passenger would write down positive and negative experiences of any kind. This helped to absorb and buffer negative experiences and helped the users to stay focused on the improvement of the system. All this lead to a throughout constant participation during the long lasting field test without which the degree of matureness probably would have not been achieved.

5 Conclusions

This paper set out to discuss possible solution for common challenges for UCD within the context of complex AAL systems. The identified challenges are: enabling the user an easy **comprehension** system as a whole and **maintaining** the iterative manner throughout the project's whole lifetime. In order to tackle these challenges two extensions to UCD methodology as described in literature [8] were proposed which can be also transferred to other development methodologies focusing on users' needs like PD or STD. Innovative service concepts within the field of AAL, like in Mobia, are designed for vulnerable persons as main users. Developing for or with this user group, experience has shown a mandatory requirement concerning continuous interaction between developers and users [2,6]. Taking this into account, this paper described a way of making complex AAL systems comprehensible for the users during initial development and showed how to maintain the iterative character of UCD and at the same time allow for a continuous development during the whole lifetime of a project. The first extension is the early stage usage of a large board game serving as a simulator of, in this case, public transport allowing both the users to experience and developers to observe the users in a quasi-realistic setting. The second extension is a longitudinal field test accompanied by regular meetings with a project friendly user base.

Evidence for the efficacy of these two extensions is provided by data from the Mobia project which applied the proposed methodology. The simulator provided an easy way to understand the multi-actor multi-artefact AAL system and enabled the acquisition of rich qualitative data concerning not only interfaces but overarching interaction within the whole system. Moreover, the descriptive statistics from the longitudinal study show how recurrent evaluative meetings – regulars' tables – helped to accompany and keep a fixed user base on the one year lasting operational test. Building upon this promising use case, one can say that extended UCD methodology is still an excellent choice where research focusses on users' need. Correctly applied, it has the potential to move innovative ideas into mature and sustainable systems.

Building upon these results, a five-year project started in late 2015 – MobiSaar – with a larger consortium extending the Mobia system to cover the whole federal state of Saarland[5]. This includes particularly finding ways to provide transportation within and outside the public transport spine for everyone.

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[5] See https://en.wikipedia.org/wiki/Saarland. Saarland has ~1 Mi habitants, 390 habitants per km^2 and one of the highest ratios cars per habitant in Europe.

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