Improving the Accessibility of Public Digital Terminals through Personalisation: Comparison of Direct and Indirect Interaction Modes

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Abstract. The APSIS4all project has developed and evaluated two different approaches to improve the accessibility of Public Digital Terminals (PDTs). The first one implements the approach called 'direct interaction', by using an online tool to collect users' needs and preferences and use them to provide personalised PDT interfaces. The second one implements the approach called 'indirect interaction', by using a smartphone make the operations and receive and 2D code to finalise the service in the PDT. This paper analyses and compares the results of the trials with both approaches, focusing on the impact of accessible and personalised services in the user experience of different user groups.

Keywords: Accessibility, Personalisation, User Experience, Public Digital Terminals, Automated Teller Machines, Ticket Vending Machines.

1 Introduction

1.1 Accessibility of Public Digital Terminals (PDTs)

Public Digital Terminals (PDTs), also known as self-service terminals (such as automated teller machines (ATMs), ticket vending machines (TVMs), virtual kiosks, etc.), play a key societal role by providing autonomous access to essential services on a 24/7 basis. Moreover, their presence in the urban environment is increasing, showing the trend towards a self-serving economy. For example, there were 435,000 ATMs in the EU at the end of 2012 [1].

However, a wide range of users found barriers that mean some citizens are unable to access PDT services, thus limiting people's ability to fully participate in society. Barriers that are frequently mentioned include the lack of speech output, the complexity of interfaces or difficulties for handling physical controls [2-3]. In many cases, there are not alternative methods for accessing the services when citizens cannot use the terminal and many of them are not supervised. In order to cope with these barriers, different standards, accessibility guidelines and solutions (e.g. speech technology or high-contrast interfaces) have been developed during the last years [4-5]. Despite all

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these valuable initiatives, the accessibility status of PDTs is still moderate in European countries, as well as other countries as Australia or USA [6].

1.2 The APSIS4all Project

APSIS4all [7] is a pan-European consortium of industry partners, research institutes and organisations which represent disability groups with the goal of making PDTs more accessible and usable. This includes adaptive interfaces offering users a personalised service adapted to their needs and preferences, and thereby overcoming the existing accessibility barriers.

Within APSIS4all, and with the aim to validate, in real life settings, the impact of providing customised interaction modes, a pilot on Automated Teller Machines (ATMs) for banking services and a pilot on Ticket Vending Machines (TVM) for transport services is taking place in Spain and Germany respectively. During these pilots, two different approaches are being implemented and tested:

Direct Interaction. Users specify their needs and preferences by using a web application. They are able to change the text size, background colours, include voice output options, add help content or simplify the interaction, among other features. This information is coded (according to specification EN 1332-4 [8]) and stored in a user device such as a contactless smartcard. Because it is based on standards, the PDT will retrieve the user's needs and preferences, regardless of the service provider, and display the most suitable interface available. See Fig. 1.

Fig. 1. Diagram representing the user journey with the direct interaction mode

Indirect Interaction. This second approach shifts the PDT operation to the Internet, so users can operate on their laptop or smartphone which is already configured according to their needs and preferences and have the corresponding assistive technologies installed when necessary. The user requests the desired service and the system generates an identification item, such as a 2D-barcode, which is transmitted to the customer's mobile phone. Finally, the user presents the 2D-barcode in the PDT and finish the payment process to obtain the service. See Fig. 2.

Fig. 2. Diagram representing the user journey with the indirect interaction mode

2 Methodology and Tools

2.1 Evaluation Framework

The development and implementation of both direct and indirect approaches has followed a Human Centered Design (HCD) process, during which near 300 users belonging to different user groups (i.e. blind, low vision, deaf, hearing impaired, motor impaired, people with intellectual disabilities, elderly people or people without disabilities) have participated in evaluation activities as surveys, usability testing and interviews (See [9-10] for a detailed description of previous user research activities).

As an important part of the HCD process, different user experience (UX) evaluations were performed in pilot sites. The evaluation framework adapted state-of-the-art techniques and questionnaires for assessing five dimensions tapping user experience with PDTs: ease of use, learnability, satisfaction, expectations and fulfillment of human needs [11-12]. By averaging the score on these individual measures, a combined single UX metric was also computed to summarize and make comparisons between user profiles. The UX metric score can range from 0 to 100, considering scores between 50-70 points as '*Just OK*', between 70-80 points as '*Good*' and above 80 points as an '*Excellent*' user experience. Together with this UX metric, both quantitative and qualitative data have been collected over the trials in APSIS4all through interviews and facilitator diaries.

2.2 Description of the APSIS4all Solutions

The Direct Interaction Approach. Direct interaction requires implementing a user modeling process where the needs, preferences and the most appropriate interfaces are covered. Along this process, the users should interact with two different solutions.

Collecting Tool of Needs and Preferences (CTNP)
A web application was designed to gather information about users' capabilities in order to define the *User's Needs and Preferences Profile* that will be later on coded and stored in the user smart card. The CTNP shows an interactive questionnaire that the users have to fill in after getting registered in the system webpage [13].See Fig. 3.

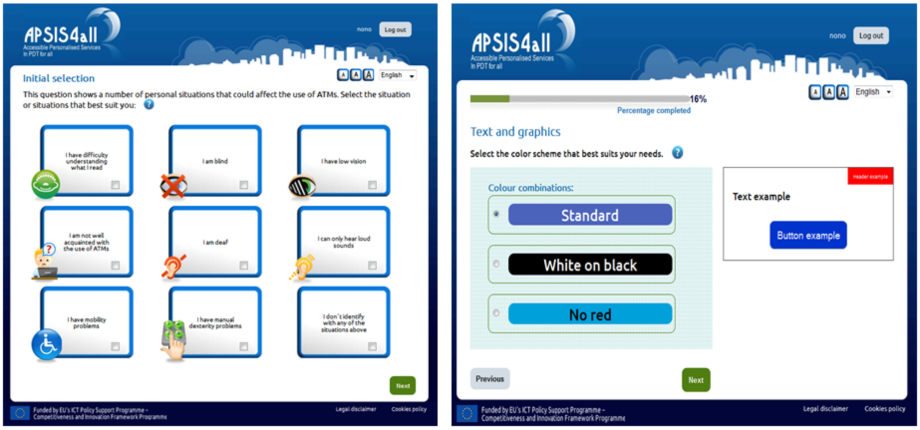

Fig. 3. Screenshots of the Collecting Tool of Needs and Preferences (CTNP)

Personalised ATM Interfaces
The accessible ATMs map the users' profiles with personalized user interfaces that take into account user requirements. Some of the available options include the use and configuration of screen readers, different high contrast interfaces, keyboard or touch screen use, simple interfaces or sign-language avatars (see Fig. 4 as an example).

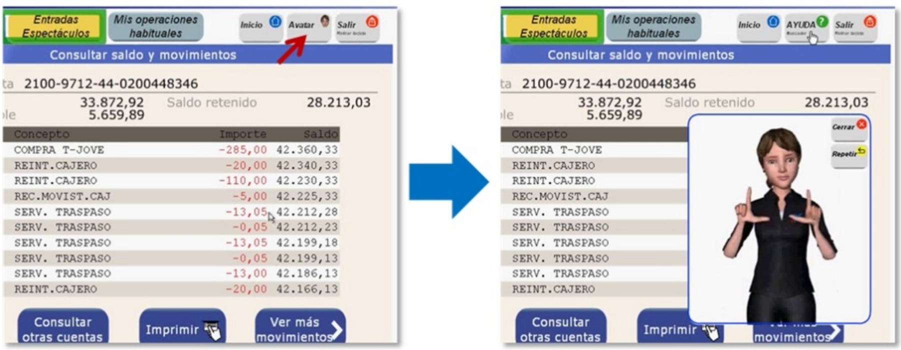

Fig. 4. Screenshot of the personalized ATM interface with sign-language avatar

Indirect Interaction Approach. In the indirect interaction approach, the users should first use their own smartphone to purchase the travel ticket through a Mobile web app, and then go to the TVM to finalize the service.

Mobile Web App
An accessible mobile web allows buying tickets and predefining the user preferred travel destinations as favorites. After that, the user receives a 2D-barcode that should be presented in the TVM to finalize the service and get his/her ticket.

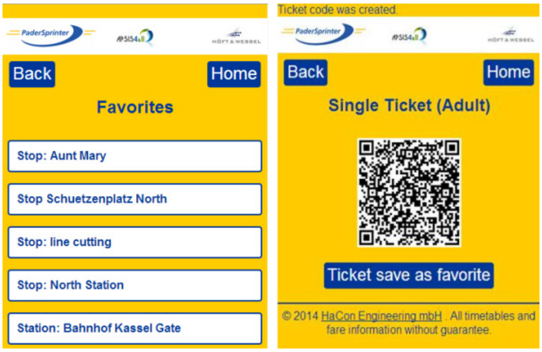

Fig. 5. Screenshot showing the list of favorite tickets (left) and the barcode generated (right)

TVM with 2D Barcode Reader
The main interaction element of the TVM in this trial is the 2D barcode reader that is used to read the barcode that have been previously created with the Mobile web app. After reading the barcode and finalizing the service, the TVM will produce the travel ticket (See Fig. 6).

Fig. 6. Picture of a user with the TVM and diagram showing the 2D barcode reader location

2.3 Participants

Table 1 shows the distribution of users that participated in research activities (field studies and user testing) for the direct interaction (ATMs, in Spain) and indirect interaction (TVMs, in Germany) approaches. There were participants from the following user groups: blind (B), visually impaired (VI), deaf (D), hearing impaired (HI), motor impaired (MI), cognitively impaired (CI), elderly people (E) and non-disabled people below 65 years old (ND). Overall, near 300 people participated in field studies and more than 200 in user testing activities during trials.

Table 1. Distribution of participants per user groups and test site

	(B)	(VI)	(D)	(HI)	(MI)	(CI)	(E)	(ND)	All
D.Int. (ATMs)									
Field studies	18	29	14	11	33	16	20	43	166
CTNP testing	16	16	15	7	14	13	10	9	100
ATM testing	4	4	4	4	4	4	6	4	34
I.Int. (TVMs)									
Field studies	10	15	13	11	16	12	25	34	125
TVM testing	3	3	3	3	3	3	6	5	29

3 Direct Interaction with Automated Teller Machines (ATMs)

3.1 Previous Experiences with ATMs and Existing Accessibility Barriers

Frequency of Use. ATMs are widely used in Spain. However, 22,23 % of the users participating in field research claimed not to use them. The lack of use of ATMs was more important for certain user groups (e.g. 50% cognitively impaired or 30% of elderly people never use ATMs, against 14% of non-disabled people younger than 65).

Usability and Accessibility Barriers. Considering the whole user sample, the most frequent problems found are the unclear and difficult to understand interfaces (experienced by 22,6% of the users) and the mismatch between ATM options and user needs (experienced by 14,4% of the users). Some of the barriers affecting specific users groups include the impossibility of reading screen content (38,9% of the blind and 60% of the visually impaired users), the inadequate functioning of the keyboard or other technical elements (33% of the motor impaired users) and the lack of instructions on the procedure (28,9% of the elderly people and 19% of the cognitively impaired users). Interestingly, it should be noticed that some of the difficulties was claimed by more than 35% of the non-disabled, younger than 65 years people. This suggests that the benefits of usability and accessibility improvements are not limited to people with disabilities and are extensive to a wider population of users.

Previous Experiences and Expectations for Future APSIS4all ATMs. The user experience with existing ATMs cannot be considered as ‘Good’, but at least ‘Just OK’ taken into account the whole sample of participants (M=57; SDE=2,54). However, a closer look at the results showed poor user experience of specific user groups as the motor impaired (M=27,35;SDE=7,72) and blind people (M=49,3;SDE=5,58).

The expected user experience with the future APSIS4all ATMs was also measured after experiencing the CTNP. The results showed a general improvement on UX scores in comparison with the existing ATM systems (M=82,44;SDE=1,70), which means that users values the APSIS4all concept and expect to have an ‘Excellent’ user experience when using future systems. See Fig. 7.

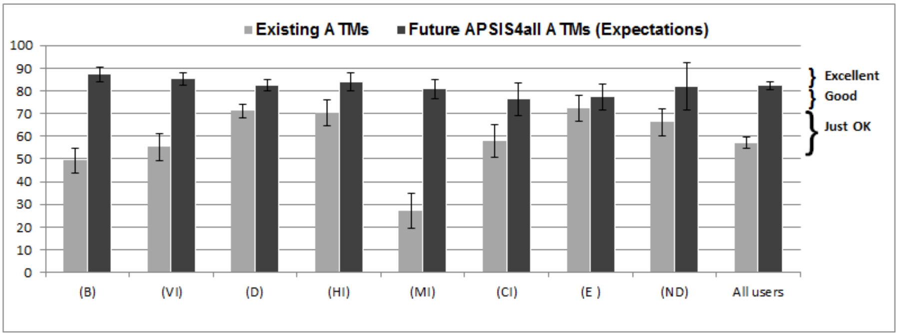

Fig. 7. Overall user experience with ATMs (existing vs. personalised) for each user profile

3.2 User Experience with the CTNP

The development of the CTNP followed a Human Centered Design approach through different design iterations, which led to improvements in the user experience in comparison with first prototypes. The process and full results are described in [9].
Results from UX questionnaires, summarized in Fig. x, have shown that the CTNP was very positively valued by the participants (M=79.06; SDE=1.84) without big differences between user groups (See Fig. 8).

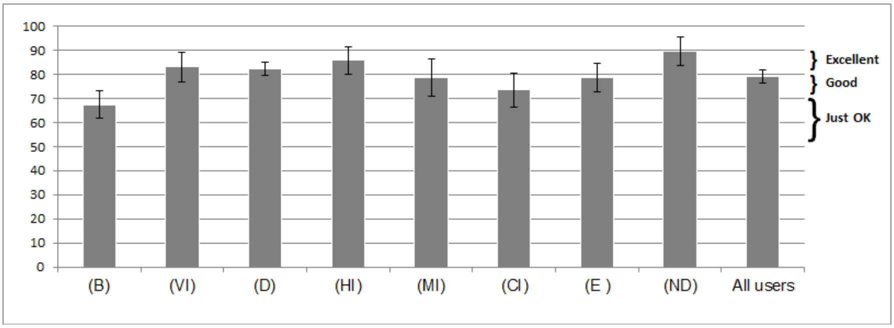

Fig. 8. Overall user experience with the CTNP for each user profile

During the evaluation process, some interesting insights were gathered while interviewing and observing users, which will help the project to improve the CTNP:

Reduce the Number of Questions. In early prototypes, users answered more than 8 questions on average to produce a complete set of user needs and preferences. However this required much effort from the users to make selections that could be inferred directly by the tool. To improve this, the current version show a reduced set of questions that can be complemented later on if needed through an 'Advanced settings' section.

Include Previews. In order to answer some questions, the users need to know what will be the consequences in the final ATM interface (e.g. How a sign-language avatar looks like? Where will it appear in the interface?). Example screenshots and animated graphics are shown in the CTNP to illustrate the aim of questions.

Limit the Number of Personalisation Options. Personalisation options are potentially unlimited. Early prototypes of the CTNP allowed choosing between 8 different colour combinations of the interface. However, this placed a burden in the user that had doubts about which of the interfaces would be the best for him/her. The current version of the CTNP offer a limited number of personalisation options based on previous user selections (e.g. if the user have problems with certain colours, it is possible to choose between a 'black&white' or 'avoid red" interface).

3.3 User Experience with ATMs

The analysis of results from questionnaires showed that, in general, the UX with APSIS4all ATMs can be considered as good (M=82.11; SDE=3.92). Results for each of the user groups were very valuable to identify future improvements, but should be taken carefully due to low number of participants per group (See Fig. 9).

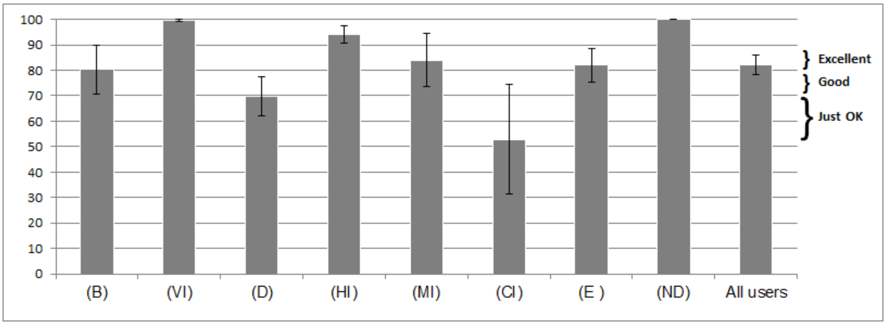

Fig. 9. Results on user experience with ATMs for each user profile

The 34 participants completed the user testing tasks without finding remarkable barriers. Some interesting ideas were expressed that are useful to improve the accessibility of ATM interfaces:

Accessibility Features Should Not Interfere with the Usability of the Interface. For example, in early prototypes the continuous appearance of the sign-language avatar caused confusion for some deaf participants. The current sign-language interface can be activated and deactivated by the user on-demand.

Remove Severe Barriers First. Some problems can even impede the use of PDTs and when these are overcome other barriers seem easier to get over. For example, participants with dexterity problems acknowledged the advantages of using a contactless card, since they hardly could reach and handle the card slot with other ATM models. Even the use of cursor navigation needed some practice they successfully completed all the tasks.

4 Indirect Interaction with Ticket Vending Machines

4.1 Previous Experiences with TVMs and Existing Accessibility Barriers

Frequency of Use. Taking into account survey responses from all user groups, 35,2% of the participants claimed not to use TVMs. Certain user groups had higher percentages of lack of use (e.g. 60% of elderly people, 58,3% of the cognitively impaired or 40% of blind people never use TVMs, against 12% of non-disabled people younger than 65). In order to interpret this data properly it has to be noticed that some user groups with severe disabilities can use public transportation for free in Germany, which surely explain their low use rates.

Usability and Accessibility Barriers. Considering the whole user sample, the most frequent problems found with TVMs are related with menu navigation and the mismatch between the available options and user needs. Some of the barriers affecting specific users groups include poor touch-screen sensitivity (63,9% of the motor impaired) and problems with the understandability of the interface (100% of the cognitively impaired users).

Previous Experiences and Expectations for Future APSIS4all TVMs. Considering the whole sample of participants, it can be said that previous experience with TVMs was perceived as sufficient (M=65.19; SDE=3.15), even when some user groups showed lower UX scores (e.g. UX score of the motor impaired users seems to be very poor; M=33.5; SDE=8.68). After knowing the APSIS4all concept and testing some prototypes, the expected user experience with future TVMs improved in comparison with the existing ones in more than 10 points (M=75.59; SDE=1.98). However, data on previous experiences didn't include impressions from blind or deaf participants who have not used TVMs before. See Fig. 10 with data from all user groups.

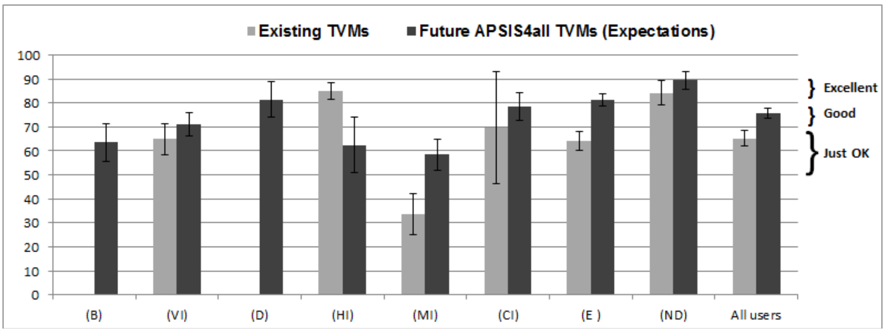

Fig. 10. Overall user experience with TVMs (existing vs. personalised) for each user profile

4.2 User Experience with the Mobile Web App

In general, the Mobile app was rated as excellent in terms of user experience according to responses to questionnaires (M=85.06; SDE=3.75). Fig. 11 shows differences between users groups that seem to be not big.

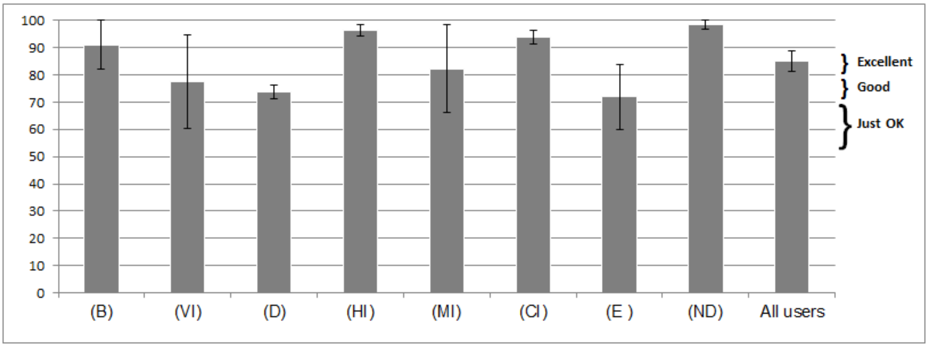

Fig. 11. Overall user experience with the mobile app for each user profile

User experience evaluations were also performed regarding the ease of use of the scanning of the 2D barcode in TVMs. This task received medium scores on average but had a wider variability between user groups (M=60.4; SDE=7.38). See Fig. 12.

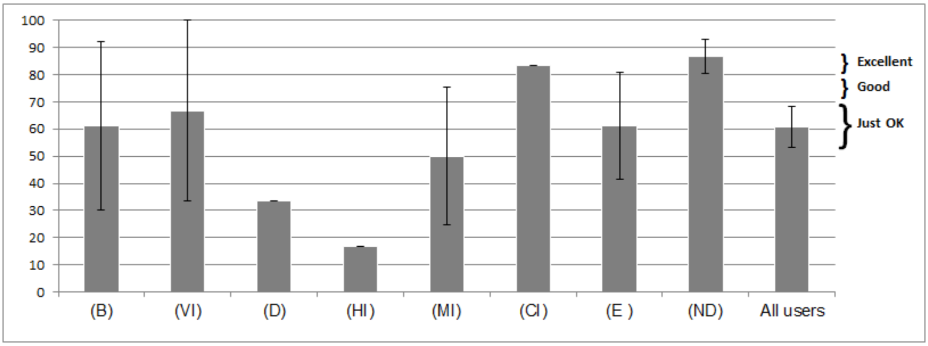

Fig. 12. Ease of use of the scanning procedure in TVMs for each user profile

The following considerations can be extracted when looking at specific user groups:

Scanning Bar Codes Requires Some Training. All participants used the Mobile web app without problems. However, for most of the users it was the first time scanning barcodes and for some of them it was very difficult to find the right angle or place under the scanner.

Blind People were the More Enthusiastic User Group. Many blind people have an accessible smartphone (e.g. iPhone with voiceover function), that they use for many different tasks in daily life. Since most of these users had not previous experiences with TVMs (i.e. because they have free access to public transport) and frequently find barriers in similar PDTs, the use of mobile phones was valued very positively.

Some User Groups May Prefer Using the TVM Directly. Even when some users may have not found big problems when using the Mobile web app and scanning the barcodes, they still can prefer a traditional way of interacting with TVMs because they already master the procedure.

5 Conclusions and Future Developments

5.1 Comparing Direct vs. Indirect Approaches

The APSIS4all project is evaluating two different approaches for providing accessible and personalized access to PDTs. As an important step in this process, this paper has described field studies and user testing conducted to evaluate the direct interaction approach (using first an online tool and then operating directly with ATMs) and the indirect interaction (using a Mobile web app to operate indirectly with TVMs).

First of all, user research has shown that there are several accessibility barriers affecting both the users of existing ATMs and TVMs. This fact is partially responsible for a lower use rate in both contexts for some user groups (e.g. cognitively impaired or elderly people) if compared with people without disabilities younger than 65 years.

Starting from this situation, it is not surprising that, in general, the expectations of the users about the future APSIS4all PDTs are more positive in comparison with the evaluation of the existing ones. However, there are differences between both approaches: while the APSIS4all concept seems to be equally valued by all user groups when applied to the Spanish ATM context, there are some confronting ideas when applied to the German TVM context. This could be partially explained by the current lack of use TVMs for some users in Germany, which may have influenced their perceptions about the provision of accessible PDT services.

Regarding the user experience evaluation of the APSIS4all solutions, it resulted in generally positive scores for the applications tested. For direct interaction, the UX scores obtained can be considered as ‘Good’ for the CTNP and ‘Excellent’ for the ATM interfaces. For indirect interaction, the Mobile web app obtained UX scores that can be considered as ‘Excellent’, but the ease of use of the barcode scanning process was rated as ‘Just OK’ on average, with high variability between user responses. This suggests that the indirect interaction mode may be not suitable for all type of users.

5.2 Next Steps in APSIS4all

Using the results of the evaluation procedure described here, the APSIS4all solutions used in the direct and indirect interaction modes have been improved before the project pilots in real environments.

The Spanish pilot implements the direct interaction in 1000 ATMs by the Spanish bank “la Caixa” in Madrid and Barcelona, whereas the German pilot will tests both the direct and the indirect interaction approaches in 24 machines deployed by TVM manufacturer Hoeft & Wessel and used by the Padersprinter transport company in Paderborn. Up to 3,000 customers are expected to use them during the pilot period which has been running for six months since the end of 2013.

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