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DESIGN AND USABILITY FOR PERSONALIZED USER INTERFACES OF TELECOMMUNICATION SERVICES

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ABSTRACT

Today user interfaces become very complex due to a rich functionality, especially services in the telecommunication area. As a consequence users neglect most of the possible functions. Till now investigations in the area of usability engineering did not yet solve this challenge. We propose a new personalization approach that incorporates design and engineering in order to reduce the amount of features of an interface. The personalization is received by determining in a first step the features of an interface that can be adapted to users' habits and preferences. In a second step these features are mapped to input/output modalities which are chosen by the user. This personalization method is based on the conceptual model of *stepping stones* that combines usability engineering with design. Usability engineering applies an iterative model to ease the usage of interfaces. Within this iterative model the stepping stones incorporate design in order to make the usage of service interfaces more intuitive.
The developed model of the stepping stones is applied to a configuration manager for cellular phones. Users can easily configure his/her personal menu structure, can add his/her favorite features and style or can delete unused features that he/she does not want to have on the phone. Finally, the configuration manager interface and its design are evaluated based on a scenario for three different user groups.

Keywords: User Interfaces, Personalization, User Requirements, Functional/Value Analysis

1 INTRODUCTION

In this paper we provide an engineering design approach to personalize user interfaces as they are assigned to telecommunication services. Today, numerous telecommunication services exist and their number grows rapidly [1]. Each such service has an own user interface with specific functions. As a result a user has to learn the interaction logic of several (different) user interfaces. This learning task prevents someone to use a service with an unknown user interface. Alleviation of this hindrance is brought by personalization [4]: the idea is that user interfaces are adapted to personal preferences and usage habits. Personalization is the process of tailoring a system, content or interface to a single user depending on information about this user. As an example consider the Multimedia Messaging Service (short: MMS), where someone can send mobile text messages enriched with pictures and sound [13]. If a user applies MMS to text and picture messages only, then the interface can be simplified by omitting the sound feature. Furthermore, if this user always sends MMS to another mobile and not to fixed line phones, then the fixed line phone numbers can also be omitted in the phone number selection menu. Finally, the user interface for MMS is simplified according to a user's usage habits.
How to achieve the personalization of interfaces? This question affords further challenges like which features of an interface to enable for personalization, how to adapt features manually or automatically, or when to stop the personalization? The latter question has the property that an interface with only one feature cannot be simplified anymore. An example is the sole textbox of Google's™ search engine interface, where a user can enter spot words. However, only a limited number of users knows specific features of this input box like "filet mignon –bone", where the spaces mean "AND" and the minus symbol "-" means WITHOUT.
Another big issue to deal with is the question up to what extent personalization is wanted and accepted by the user [3]. Adaptation of interfaces is a continuous process [10]. Obviously, it has to be ensured

that users are not irritated by modifying interfaces. Hence, this should be a fairly slow process. The adaptation can be done purely manually or with system support resulting in an automated adaptation. In this paper we focus on the manual adaptation in order to show how to come to useable, personalized interfaces. Therefore, we also consider motivations and barriers from the user acceptance point of view.

Personalization of interfaces has the danger that interfaces may become patchwork look, when parts of them are omitted or modified. Hence, the design of interfaces and especially, their service to the adaptation has an important role. In the conceptual model of the *stepping stones* below, we describe how to incorporate design into the usability engineering process of adaptable interfaces. Usability engineering is the idea of iterating requirement analysis, prototyping, and testing, until a useable interface has been created [2].

The conceptual model depicts how the parameters interface, user, design, and implementation are linked up within the development process of personalized interfaces. The metaphor of "stepping stones" describes that all steps taken are related to each other and that one can step back, iterate, and forth, to achieve the project goal. In this paper we apply this conceptual model to develop a configuration manager for mobile phones. The idea of the configuration manager is to provide a Web-based interface that allows users to configure their cellular. Part of the configuration is the deletion or assertion of services to the mobile phone. A recommender helps the user to find new services based on his/her usage habits. For this configuration manager a user group evaluation on personalization is performed, and interface designs visualizing personalized interfaces and service structures are depicted. These designs are implemented as a web service. The usability testing step is performed and analyzed. Finally, an optimized prototype is yielded that enhances the user satisfaction. This case study demonstrates the power of the conceptual model for the stepping stones and its incorporation into usability engineering.

The paper is organized as follows: the personalization of interfaces based on different taxonomies is described in Section 2. As a result interface technologies and modalities for the personalization are yielded. Section 3 explains the conceptual model of the stepping stones to development projects that follow the iterative design approach. With this model interface and interaction design, usability testing, and implementation are connected to each other. For the evaluation a configuration manager for cellular phones is described (Section 4). Then, the stepping stone model is applied to the configuration manager in Section 5. Three different user groups are applied to evaluate its usability and design. In Section 6 we conclude with a summary of the results and future work.

2 PERSONALIZATION OF INTERFACES

The personalization of interfaces is derived from three taxonomies of interfaces with different perspectives: 1. interfaces that are running on devices which can be clustered based on their availability (product, prototype, research), 2. interface technologies with respect to their developed purpose like user authentication, and 3. a taxonomy of input / output modalities with a mapping of the interface technologies to the modalities. These taxonomies are considered in the following.

The market availability of an interface is determined by the maturity of the device on which the interface is operating. Three different categories are known for the availability of a device / interface [12]: products are already in the market, prototypes are known to be available in mid-term, and pure research items are long-term investigations. Most prominent for these interfaces are the keyboard, mouse, trackball, graphics tablet, touch pad, and the monitor / screen. Further common interfaces are Braille display, joystick, force feedback mouse, loudspeaker, microphone, headset, touch screen, (Web) camera, head mounted display with camera, smart card reader, and 3d display. In close future the field of vision-based interfaces is expanding by data glove, 3d mouse, holotouch, electrode retinal display, brain interface, and chip implant. However, the latter types may demand a surgery at the human head which can reduce the acceptance. Another future type of interface refers to the olfactory- and taste-based interfaces. These interfaces are far in the future since the creation of odor and taste is still a research topic.

Interfaces allow a user to perform a pre-specified set of tasks [10]. The user-interface interaction is strongly related to the technologies that an interface provides. Five different classes of technologies can be considered [12]:

- Basic technologies: electronic ink, handwriting capture, natural speech, and Braille display.
- Extended technologies with interpretation of captured input: gesture recognition, gaze tracking

(eye-tracking), speech recognition, lip-reading, emotion recognition, sound source localization, and activity detection and recognition.
- Authentication technologies: authentication via secure encryption, iris scan, finger tip scan, and 3D laser scan.
- Electronic interfaces: location sensing and muscle tension.
- Specific technologies for spatial selected output: vibrotactile alarm and audio spotlight.

Visual Input	**Auditory Input**	**Tactile Input**	**Kinesthetic Input**
• Gesture recognition • Gaze tracking • Lip-reading • Emotion recognition, activity detection and recognition • Iris scan • Finger tip scan • 3D laser scan • Location sensing /LBS	• Natural speech • Recognition with microphone / headset • Emotion recognition • Location sensing with microphone arrays	• Pressing key • Handwriting capture • Touch screen • Gesture recognition with data glove • Finger tip scan	• Moving pointing device • Gesture recognition • Lip reading with face sensors • Gaze / eye tracking • Emotion recognition • Holotouch
Visual Output	**Auditory Output**	**Tactile Output**	**Kinesthetic Output**
• Monitor / touch screen • Head-mounted display • Holotouch • Retinal display	• Audio spotlight • Natural speech	• Braille display • Force feedback of mouse or data glove • Vibrotactile alarm	• Force feedback • Vibrotactile alarm

Figure 1. Four modalities for sensors: visual, auditive, tactile, and kinesthetic. The modalities are distinguished for input and output. Interface technologies are assigned to the modalities.

Depending on the interface and the task someone aims to perform he/she must be able to operate these technologies. Fortunately, knowledge about these technologies is not necessary, since interfaces and supporting systems can hide technological details like caching of data during the display of a video stream.

Humans communicate in a multimodal manner, where they apply different media like voice, gestures, and mimik. These media are often applied in parallel. Analogously, sensors can be sorted by four applicable modalities (Figure 1): visual, auditive, tactile, and kinesthetic sensors. The modalities have to be distinguished for input and output technologies. To each sensor modality is assigned a set of interface technologies, e.g., tactile input can be applied to interfaces on touch screens. The forehand described taxonomies define the personalization options that exist for interfaces.

Personalization addresses the adaptation of a system / interface to users' behavior and preferences. Hence, users need to experience the interface, e.g., by a prototype. Usually, the experience is achieved by interactions with the interface. Personalized interfaces improve the experience users have with interfaces, since personalization reduces complexity and tailors interfaces to users' demands [10].

For the personalization of interfaces there are several options: Trivial solution is to omit menu options as is done in roll-up windows by Microsoft Windows™ (Figure 2). This so-called *anonymous personalization* does neither adapt an interface to the user behavior nor to user preferences.

Nevertheless, it reduces the complexity of the menu structure, and additionally, it can be executed fully automatic by the interface, i.e., the user has not to initiate this personalization method. In contrast to the fully automatic personalization a more individual approach is to design interfaces according to the user's behavior with respect to personal preferences and usage habits. In this case the applied interface technologies and modalities are personalized. The personalization is performed based on the stepping stones in the following section.

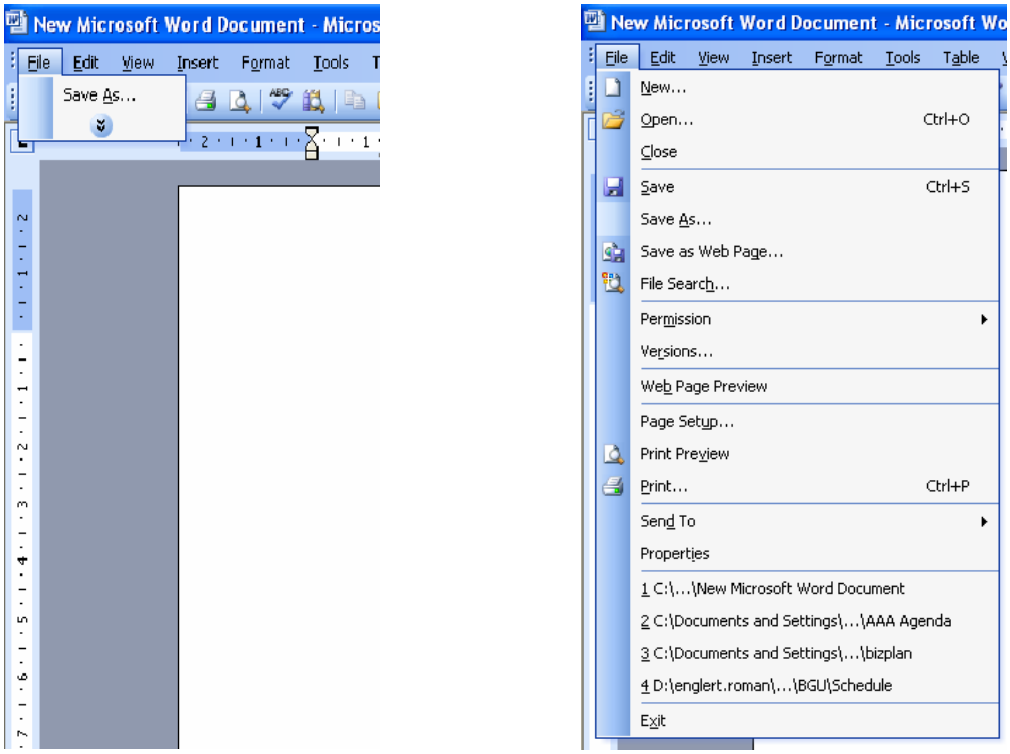


Figure 2. Anonymous personalization: Folded and unfolded roll-up windows.

3 CONCEPTUAL MODEL: STEPPING STONES

The conceptual model of the *stepping stones* shows the steps within the project lifecycle that are taken to come up with a prototype for a personalized user interface. This model is a general approach for development projects that follow the iterative design approach. The potential for innovation lies in the tight connection of interface and interaction design, usability testing, and implementation, that is iterated several times. With this approach, we make sure that first, the design is an integrated part in the development process at an early stage, second, that early design ideas are tested on actual users and that they are evaluated, and third, that the first results of technical implementation go again through an iteration of design and usability testing. This approach ensures that the user is involved in the development process as stated in the user centred design method. In the field study presented in this paper, it took about 12 months of time to perform these steps from the first analysis to the last iteration of design and implementation.

The conceptual model has the following six steps (Figure 3):

1. A taxonomy of interfaces
2. A study on the dimensions of personalization
3. A study of user groups
4. A mapping of results from steps 1 – 3
5. Interface and interaction design
6. Implementation and usability testing

The conceptual model starts with a basic analysis of interfaces that are relevant for telecommunication services. An interface is not a thing, but a dimension that structures the interaction between user, tool, and task, as Gui Bonsiepe puts it [4]. The analysis is focusing on the potentials of interfaces for personalization. The challenge of this first step is to understand the interaction between the three

parameters user, tool, and task, and their ability for personalization, that means the adaptation or tuning in of an interface to an individual person or to groups of people. Output of this first step within the conceptual model is the shown taxonomy of interfaces ordered along the input and output modalities: visual, auditive, tactile and kinesthetic input and output (Figure 1).

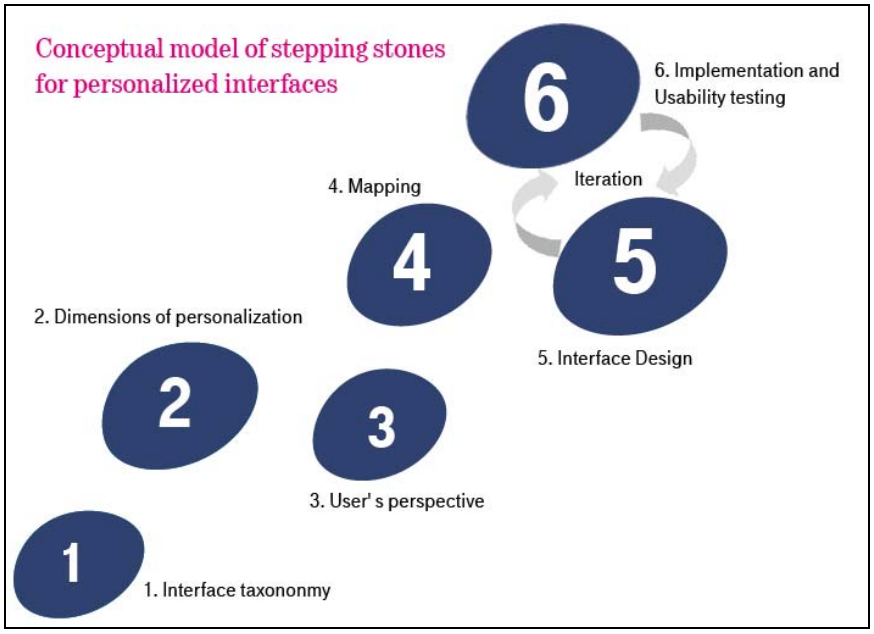


Figure 3. Conceptual model of stepping stones.

Second step is a study on the dimensions of personalization. The term *dimension* describes – as stated in the definition of an interface – the core character of the interface itself. Each interface that was scouted within the first step is now analyzed with regard to its personalization properties. Here, personalization is composed of two distinct features, namely *adaptive* and *adaptable* properties:

- adaptive – adaptivity: passive personalization, implicit personalization, automatic personalization, system-driven personalization
- adaptable – adaptability: active personalization, explicit personalization, manual personalization, user-driven personalization

An example for an adaptive service is the book suggestion of Amazon. It is based on what the user has previously bought, as well as by the purchases of other customers who purchased similar books. An example for an adaptable service is the interface of MyYahoo™. Here, the user can actively decide which items he/she wants to be displayed. Different interfaces – as they are part of products and services – have a different intensity and form of personalization. These forms are described within the second step by different levels of adaptivity and adaptability.

The third step is part of market research including demographics, focus groups, surveys and market segments [5]. At this level, a study of user groups is performed in order to understand customer's needs as well as barriers towards personalized interfaces. The question is which user group – according to market segments – will most likely have a high interest in personalization. This analysis is based on social requirements and key factors of acceptance and motivation that are gained through quantitative as well as qualitative methods of market research. In this step, it is crucial to use thorough insights into the user's perspective in order to understand motivations in a better way. Therefore, focus groups are involved before starting any design or implementation process.

The fourth step takes the output of all previous steps and maps it. The idea is to take the insights on interface modalities, dimensions of personalization, as well as the user's perspective, and combine them in a mapping. This mapping shows the results that are true for all three previous steps. Therefore, it forms the input for the design and implementation of the prototype. Based on these results, service scenarios are developed following a scenario based development approach. The scenario illustrates an example of a future system usage; in this case it illustrates the usage of personalized interfaces for

telecommunication services. This is an important step towards a first prototype because with the scenario we gain first high level requirements for design and implementation [6].
The last step starts with the transformation of results into first sketches for the prototype [7]. Within this step, interface as well as interaction design is performed. Interface design deals with the concept and visualization of the interface the users gets in touch with while using the product or service. It is closely linked to interaction design that focuses more on the dynamic action and interaction between user and interface, e.g. the activity chain of action and reaction between user and system. Interface and interaction design complete each other. On the one hand, they include conceptual and aesthetical considerations [15]; on the other hand, they deliver technical requirements for implementation and programming. Within this step, first usability tests are performed in order to prove the quality of concept and design perceived by the target group.
The last step consists of the implementation and iterative usability testing. It implements the results of the interface and interaction design according to technical requirements as well as results of the usability testing. The technical implementation leads to a first demonstrator or a so called click dummy that is tested on its usability and user acceptance as described in ISO 9241-10 [14]. Steps 5 and 6 pass iterations like described in ISO 13407 [8] in order to achieve a convenient usability and design of the interface.
These stepping stones illustrate the method that we used for the development project. The most important part is the connection of design, usability testing, and implementation: here we step back and forth in order to enhance the quality of the user interface perceived by the user in a significant way. This is particularly crucial for the development of personalized interfaces because their acceptance depends very much on a good usability as well as on a thorough adaptation to user's needs and expectations. Personalization fails if the user is irritated by a constantly changing interface or if he/she does not feel in control of the system any longer. A good interface design is one key aspect for a higher acceptance rate if good interface metaphors are found to communicate functionalities and context. Additionally, the acceptance and usability testing complement design and implementation.
In the next section the idea of a configuration manager for cellular phones is described. This conceptual model of the stepping stones is then applied to the configuration manager in order to receive the personalization for different user types.

4 CONFIGURATION MANAGER FOR CELLULAR PHONES

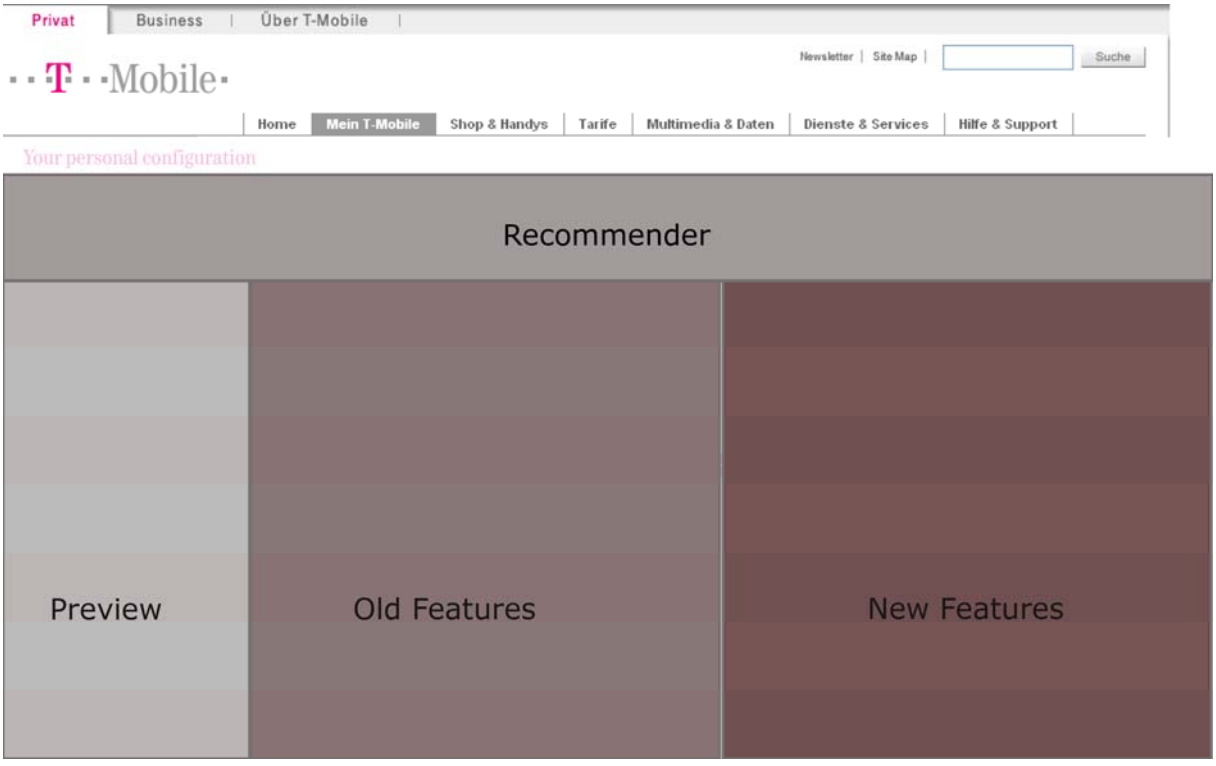


Figure 4. Concept of web interface of the configuration manager.

Today the usage of cellular phones is widespread. Due to their limited size and the broad functionality they are difficult to use. Goal of the (new) configuration manager for cellular phones is to provide a personalized mobile phone to all users. Every user can easily configure his/her personal menu structure, can add his/her favorite features and style or can delete unused features that he/she does not want to have on the phone. The configuration can be easily changed any time the user wants to – just using a web interface. Primary idea of the whole service is modularity. Each user should work with her/his favorite modules.

Main modules are (Figure 4): recommender, old and new feature lists, and a preview of the (new) menu structure. The recommender function of the configuration manager points her/him to new features that might be of interest. As an example for a new mobile service that can be added to the cellular phone consider a karaoke bar. Many phones have a music player (MPEG3) and a microphone is always available. In this case a mini karaoke service can be added to the phone, if the recommender finds the mobile service for the cellular phone. Two different feature lists visualize the before and after configurations: the old feature lists show which features a user currently has, and the new feature list depicts how the further personalized configuration looks. Primary goal is to add new features (also based on the recommender) to the phone or to remove not used or redundant features from the phone. Assume someone never uses voice control – see the auditive input modality in Section 2 (Figure 1) – to select addresses in the phone book. Then the voice control service can be switched off and removed. Finally, a preview section shows the look and feel of the new configuration (middle of Figure 4). As a result a user's cellular phone is tailored to her/his wishes and needs.

In the following the conceptual model of the stepping stones is applied to the configuration manager in order to receive an interface that is usable for users with different behaviors and needs. The configuration manager is based on a scenario that we developed for three different types of users, a teenage boy called Alan, a business woman called Clarissa and an elderly housewife called Eva. They all want to have their own, personalized cellular phone. Alan with brand new slums, ringtones and gaming features, Clarissa with effective and time saving business services and Eva just with her well known features from her former cellular phone. They all use the personal configuration manager via the Web interface.

5 USER GROUP EVALUATION AND INTERFACE DESIGN

The user group evaluation and design process were accomplished in four phases: 1. scenario evaluation with focus groups, 2. interface metaphors and design sketches, 3. paper prototyping and expert evaluation, and 4. detailed design and requirements.

In the first phase, the scenario we developed within the case study was evaluated by focus groups in order to check the acceptance rate. This step was taken before starting the first visual design to ensure the consideration of user's needs and expectations. For the evaluation, three use cases of the scenario were defined that targeted different user groups: Alan, a 13 year old teenage power user, Clarissa, a 40 year old business woman traveling a lot, and Eva, a 65 year old house wife using her cellular phone quite rarely. For these user groups the different in- and output modalities (Figure 1) were considered according to user's preferred communication modalities. E.g. for the user group "Alan" the interface could be enhanced with visual as well as kinesthetic in- and output like holotouch or force feedback because this user group is likely to be attracted by innovative interaction modalities. On the contrary, the user group "Eva" could be supported more efficiently with auditive in- and output like natural speech, because these users have to be offered interaction modes that seem less technical and more natural to them.

The acceptance of the scenarios was validated with representatives of the three target groups: first, young adults from 16 to 18 with a high interest in technical issues; second, professionals who are frequently traveling for business reasons; and third, senior citizens who own a cellular phone. Every group has been interviewed about the personalization options within the related storyboard. The approach was as follows: 1. warming up with starting questions, 2. explanation of the storyboard and evaluation by the focus group, 3. presentation of the two storyboards of the other target groups, 4. conclusive evaluation of all three storyboards with all focus groups together, and 5. questions about the monetary value of the service. The overall acceptance of the storyboards was good and fitted in most cases to the recurring target group (all ratings for the "Alan" and the "Eva" scenario between 5 and 10 on a 10 point scale). Only in the business scenario there was a lower acceptance especially due to a specific function, which was the automatic recommender (four ratings lower than 5, just one

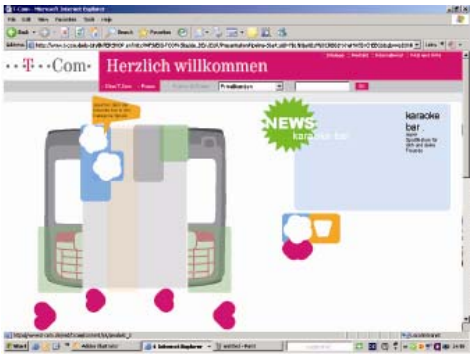
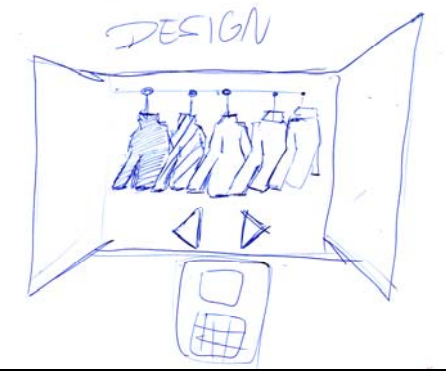
above 5 on a 10 point scale). The users were afraid about functionalities that they cannot control and that are pushed to the device automatically. Additionally, the users did not want to use their mobile phones for data transfer or blogging – functionalities that were planned in the scenario for power users in business context.

In spite of the good acceptance rate, the testing revealed that a stereotyped user typology did not fit the real needs of the target groups. We found out that e.g. some functionalities that were planned for the teenage target group fitted quite well the needs of the business customers, and vice versa. The elderly users did not want to be treated as stereotyped "elderly" and reacted negatively on the term "comfort phone". Some participants of this focus group pointed out that they want simple interfaces and a higher amount of guidance on the one hand, but on the other hand they wanted to have access to the same complex functionalities as power users. This is a general problem for the user specific development and personalization of interfaces as such, and it has to be tested in long term user tests how the actual user behaves using the service. Those testing on the service can reveal whether there is a difference in the individual user's self-assessment concerning the expected needs, and the actual long term behavior towards the service. Here, personalization again plays a major role because users can – despite of their assigned role as "power user" or "beginner users" – manually adapt the interface configuration due to their actual needs. Hence, we can overcome the problem of over-stereotyped user profiles with manual personalization.

After this first evaluation of acceptance, the storyboards were adapted due to user's comments and needs. Especially, the user-type specific approach was modified to a solution, where users are not pre-selected for one single user-category. The personalization was changed to a flexible concept were it develops over time of usage more dynamically to the users' preferences and habits.

The second phase was concerned with interface metaphors and design sketches. The question was first, what general metaphor could be found to communicate the use cases depicted in the scenario. Therefore, the design team was searching for metaphors taken as analogies from the real world that could be transferred to a digital interface [9].

Results of the research into interface metaphors are the following (Figure 5):

Use Case	**Metaphor**	**Image transfer**
Access mobile phone to upload data	Entrance door opening and closing 	
Select different skins and designs for the screen	Wardrobe with different clothes for changing 	
Display storage capacity	Balloon fills with air	

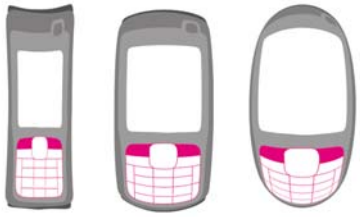
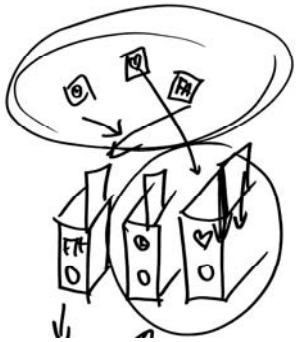
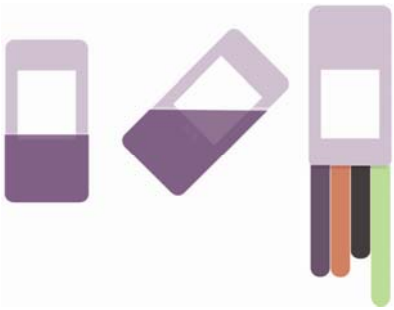
		
Organize used and unused features on the configuration manager's interface	Grid from "Tic Tac Toe" game 	
Organize data and services on mobile device due to personal needs	Drawers to store objects 	
Check all features and data stored on mobile phone	Pouring out content from water glass 	

Figure 5. Interface Metaphors.

These interface metaphors were evaluated for their usability according to Jacob Nielsen's heuristic evaluation method [10]. For example, the flexibility and efficiency of use, as well as the match between system and the real world were key factors for the evaluation of interface metaphors.
In the third phase, the team used the paper prototyping method [11] to design in detail the interface metaphor for different use cases. Before starting the final design, the paper prototyping is used to check faults or inconsequence of the concept. At this stage, interface elements can be easily added, deleted or changed without big effort. By using these evaluations and testing methods, the team sorted out many of the first ideas and sketches. Key question was how the interface metaphors can support the offered personalization features in a compelling manner. Here the assumption is that a good interface metaphor enhances the acceptance of personalized interfaces in a significant way. For

example, the idea of using a grid to organize used and unused features on the configuration manager's interface was tested in the paper prototyping method on its practicability for different use cases. The result was that the affordance of the elements was not given and that the mapping was not easily understandable for novice users. As this metaphor violated the criterion of flexibility and efficiency of use, this metaphor was not developed any further.
In the end, the team came up with an interface concept that works with more established interface metaphors, e.g. listings and windows, which meet the user's expectations in a better way.

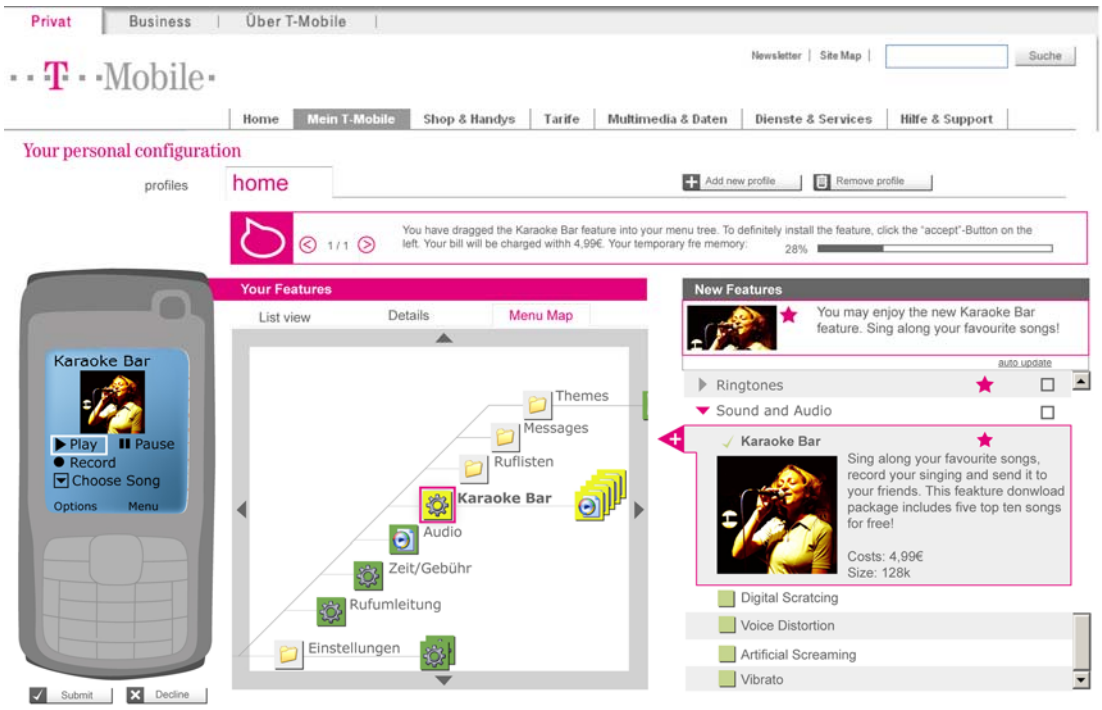


Figure 6. Prototype of configuration manager.

We created an interface that can be manually adapted by choosing a profile (power user interface, business user interface, simple interface) at first usage. This profile is selected by answering three questions about the frequency and kind of PC and ICT usage. According to the answers, a usage profile is pre-selected that coordinates the amount of support functions and feature recommendations the user gets. Power users e.g. get a visual menu tree (see middle of Figure 6) that allows a direct and playful interaction, whereas users of the "beginners" interface get a guided tour through the interaction options when they first enter the service. The amount of guidance and of system recommendations can be individually adapted due to user's wishes.
This more detailed design was tested on its usability by an external group of experts. The usability deficiencies were documented by the experts following ISO 9241-10 [14]. Furthermore, recommendations for improvements were given. The basis for evaluation was a click dummy showing the main use cases screen by screen in three different versions according to the different user groups. The expert judgment considered the prototypical interface in all three versions as good. The most important weaknesses were stated in the category affordance and appropriateness for the task. For example, some features like the recommender or the feature browser were not intuitively understandable concerning their use. Furthermore, the guidance within the profile "simple interface" had to be reworked because different functions (e.g. help and recommendation) were assembled under this feature. The guidance had to be enhanced with more information that requests user's action.
The design team reworked the interface design according to the experts recommended improvements. Hence, it was redesigned significantly regarding the distribution of interface elements so that we came up with a clear solution. E.g. user guidance was added to mouse interactions when the cursor changes to an index for interaction options. Moreover, the connection of certain interface elements was clearly indicated by a visual link in order to ease user's orientation on screen.

After this first redesign, we developed technical requirements for the implementation. According to the interface design and the requirements, the service was implemented as a Web service. Output of this process was a first prototype that was again tested on its usability. The iterations were run – corresponding to the user-centered design process (Figure 3) – three times from design, usability testing, design adjustments, to implementation, and then starting over again.

6 CONCLUSION

In this paper we have shown the new approach of the stepping stones to incorporate design into usability engineering. The stepping stones enable the personalization of interfaces that reduces the amount of interface features according to users' preferences and usage habits. The developed stepping stone model is evaluated with a configuration manager for cellular phones. The evaluation has been performed based on three use cases representing different user groups. For these uses cases five design metaphors could be found to communicate the use cases depicted in the scenario of the configuration manager. The design team took the analogies from the real world that could be transferred to a digital interface. The metaphors increased the flexibility and efficiency of use, as well as the match between system and the real world. Further improvements are received by applying the paper prototyping method to develop in detail the interface metaphor for different use cases. The paper prototyping was used to check faults or inconsequence of the concept. These steps were iterated three times with respect to their design until the test users felt intuitively confident with the configuration manager.
Future work will be done for a partial automation of the stepping stones. A design support system that eases the evaluation and provides recommendations to the designers is under investigation.

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