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Transmeta Design: adding transparency and meta-communication to Web services design

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Abstract. *In this paper, we propose an approach for enhancing the usability of Web services. Our approach is based on a set of common interaction characteristics permeating through several interaction design methodologies, such as User-Centred Design, Participatory Design, Meta-Design and Semiotic Engineering. We identified transparency and meta-communication as two characteristics of user interfaces that can be effective in enhancing Web services usability. We call the new design approach, based on the aforementioned characteristics, Transmeta Design. Finally, we present a case study that demonstrates the application of our approach.*

Keywords. Interaction Design, HCI Theory, Usability.

1. Introduction

Usability Engineering is a well-established field. Many different methodologies have been introduced in order to design for usability: *User-Centred Design*, *Participatory Design*, *Meta-Design* and *Semiotic Engineering,* among others. These methodologies focus on giving a central role to the user, either through the participation in the design process or by stimulating the users' creativity by providing them with the tools for contributing to the system content design.

In this paper, we propose a design approach based on the aforementioned interactive design methodologies, which would be particularly appropriate for improving Web services usability.

The process of evolving Transmeta Design involved three steps. In the first step we considered four design approaches (*User-Centred Design*, *Participatory Design*, *Meta-Design* and *Semiotic Engineering*) and identified relevant characteristics for enhancing Web services usability. In the second step we specified an approach based on these characteristics. In the third step, we demonstrated how our proposed strategy can be applied in order to enhance the usability of Web services.

The paper is organised as follows. Section 2 provides a brief overview of Usability Engineering, section 3 presents an analysis of four selected usability engineering approaches and identifies the common dimensions across these approaches (transparency and meta-communication). In section 4 we present the Transmeta Design matrix as a tool for the application of transparency and meta-communication to Web services. In the section 5, we describe the transparency and meta-communication features for Web services as an additional layer of a distributed multi-tiered architecture, describing the Transmeta Design approach. In the concluding section we show a use case where we employed Transmeta Design to improve the usability of the Web services for commercial flight bookings.

2. Usability Engineering

In the discipline of Human Computer Interaction, Usability Engineering refers to the study of methods, tools and guidelines for designing effective interfaces as defined in 1993 by Nielsen [7]. The main goal of Usability Engineering is to improve the interaction between users and systems trying to closely match their needs. In this section, we present four particular approaches to Usability Engineering: *User-Centred Design*, *Participatory Design*, *Semiotic Engineering* and *Meta-Design*. All four approaches meet the basic principles of interaction design processes [10]:

(i) an active involvement of users;
(ii) the definition of several usability criteria;
(iii) iterative activities along the entire process.

In 1980s, Norman and Draper presented the *User-Centred Design* methodology in which they

consider the user as the centre of the design. The objective was to guarantee that the user would be able to perform his/her tasks by minimising the cognitive effort [8]. The design process consists of four phases: gathering user requirements, analysis of these requirements, design and evaluation. The designer must identify the final user of the system and analyse required tasks.

In 1993, Schuler and Namioka [9] defined *Participatory Design* (PD) where end users, and developers cooperate during the design process. A workgroup (made by different classes of users: designers, stakeholders, end users, etc.) shares information and activities from the initial exploration of the problem to the development and the evaluation of the proposed solution. The introduction of cooperation allows users to make informed decisions and to guide the system development according to their needs. Nowadays, *Participatory Design* is one of the main choices when designing Human Centred Systems because it represents an effective balance between views of the designers and the users.

In 2000, Gherard Fisher [10] introduced the *Meta-Design* approach where the cooperation between users and designers is the focal point of the design process [10]. Similarly to *Participatory Design*, in *Meta-Design* users and designers collaborate in socio-technical environments to find a common development of Human Centred Systems. The main tough consists in the relationship between design time and use time [5]. In *Participatory Design*, the collaboration between users and designers occurs only at the design time. In Meta Design the design time continues during the use time. Users can modify the existing functionalities, add new ones or send feedbacks depending on their needs. Designers need to develop the main structure of the system and give users the tools to facilitate their involvement in the development of the system itself.

Semiotic Engineering, introduced by Clarisse de Souza [2], is aiming to improve the communication between users and designers. The origin of this approach is in the semiotic theory and its two fundamental concepts - signification and communication. In the user interfaces, a sign is a graphical way to represent an action (e.g. an icon or a label), the signification is the action associated to a specific sign and the communication is a complex activity, composed by a combination of individual actions. The semiotics represents the meta-communication between designers and users through the interface of the system [2]. In the semiotic engineering view meta-communication artefacts are characterised by a two-level communicative process—the designer-to-user communication and the user-system interaction [2]. During an initial phase, the designer studies user's activities and the domain of the application and provides a first implementation of the system that reflects his/her understanding of user's needs. At this point, users unfold the designer's message by interacting with the system and finally make full sense of the designer's message and respond to it proposing their interpretation of the system use. Misinterpretations may be threatened as instances of repurposing the signs in the designer's message, like a participatory redesign activity but at use time [1].

3. Common Dimensions

Each usability engineering approach presented in the above section follows a design process and a set of activities in order to develop systems with specific characteristics. In this section we will identify common dimensions across these approaches that might be employed for improving the usability of Web services.

We analysed several examples of systems designed following considered usability engineering approaches (i.e. *User-Centred, Participatory, Meta-design and Semiotic Engineering*). As the result of our analysis we identified transparency and meta-communication as two characteristics that are shared by all four approaches. For each example we will show how transparency and meta-communication influenced the design process.

The concept of transparency for user interfaces has been defined by Tanimoto [11]. It is to do with the visualization of system information displayed to the user such as intermediate results, processes, single activities, input data and assumptions. An example of a transparent application is the console of a computer; during booting up the console shows messages with detailed information about performed activities [11]. The granularity and the way in which the information is displayed depends on the domain and needs of users and could range, for example, from a log-file with few system messages to a tutorial with a detailed description of functionalities.

The meta-communication, instead, as defined by de Souza [2], represents semantics and interpretation rules used between users and designers during a communicative process. The level of meta-communication depends on the users' involvement. In a low meta-communication level, the user is required to understand the designer's language (i.e. the interface) to communicate with her. However, if the user and the designer define and agree on common semantics and interpretation the level of meta-communication is higher (i.e the interface matches users' intentions).

In the examples that follow we show the influence of transparency and meta-communication on the design process.

In *User-Centred Design* and *Participatory Design* the design process is quite similar, the main difference is in the participation of users during the development phase. Take for example the Hospital Project for the nursing supervisor's administration presented in [10]. The aim of this project was to develop a system that would improve the efficiency of administration activities. The system has been designed following a participatory approach that involved both the experts from hospital administration and the system designers to reach a final joint agreement. In this way, designers were aware of the real needs of experts for making administration activities more efficient. As suggested by the participatory approach, to improve the collaboration between experts and designers, it is crucial to make system activities and contents available for everybody. In this approach, we can recognize both transparency and meta-communication since: (1) the system has to be transparent, i.e., the system has to give information about its inner mechanisms (all stakeholders, administrators, physicians, etc., must be able to understand the system from their personal perspective); (2) designers and users have to share a common language with the definition of a set of signs and semantics, which corresponds to the definition of a meta-communication language (e.g. adapt the language so that it is specific depending on the user, e.g. administrative or clinical).

The example we took into account for *Meta-Design* is a project called EMPIRE [4]. The aim of EMPIRE was to develop a socio-technical environment to enhance the participation of people for managing energy sustainability and consumption. In particular, users could collaborate in both creating and modifying content depending on their role in the society. On one hand, the system needs to be sufficiently transparent to help users modifying the contents by providing to them energy consumption and waste management tools. On the other hand, designers and users have to share a common meta-communication to avoid misinterpretations, especially in case of management tools using a technical language for describing energy related issues.

In case of *Semiotic Engineering*, we selected the CoScripter [3] interface. CoScripter is a browser-based program for sharing information about Web activities. The semiotic approach works by redefining the meaning of used signs (e.g. icons) and the structure of the application itself to improve the interaction. For example, the interface presents a box to show activities performed on the Web: users have the possibility to save trails of activities and reuse them in other moments. The interface can be recognized as a possible implementation of transparency and meta-communication. In particular, the list of performed activities makes the system more transparent, while the defined semantics improves the clarity of provided functionalities in the interface.

4. The Transmeta Design matrix

In this section we propose the Transmeta Design matrix, shown in Figure 1. This is a reference tool to aid selecting the appropriate functionalities in order to design usable features for Web services. The selection depends on the level of transparency and meta-communication the designers would like to achieve. Based on [12] we identified four levels of transparency: Black-Box, Detail-Box, On Demand-Box and Glass-Box listed from the lowest to the highest level of transparency. At the lowest level, Black-Box, indicates that the Web service is considered as a black box where only inputs and outputs are displayed to the end user. The Detail-Box, shows some details about internal operations of the Web service, through a message window (e.g. Alert box) or a log file. The On Demand-Box level is similar to the Detailed-Box, but in this case the Web service provides information depending on user's request. At the Glass-Box level the Web service is completely transparent and shows all its internal activities.

We defined meta-communication as the user's involvement in the definition of a common semantics with the designer: the best case

corresponds to a complete and unambiguous understanding of designer's messages by the end user. User involvement is presented in Figure 1 as a measure of meta-communication. In the

as new functionalities to existing features both for enhancing transparency (i.e. tutorial, etc.) or for user involvement (i.e. collaboration tools, code reviews, etc.).

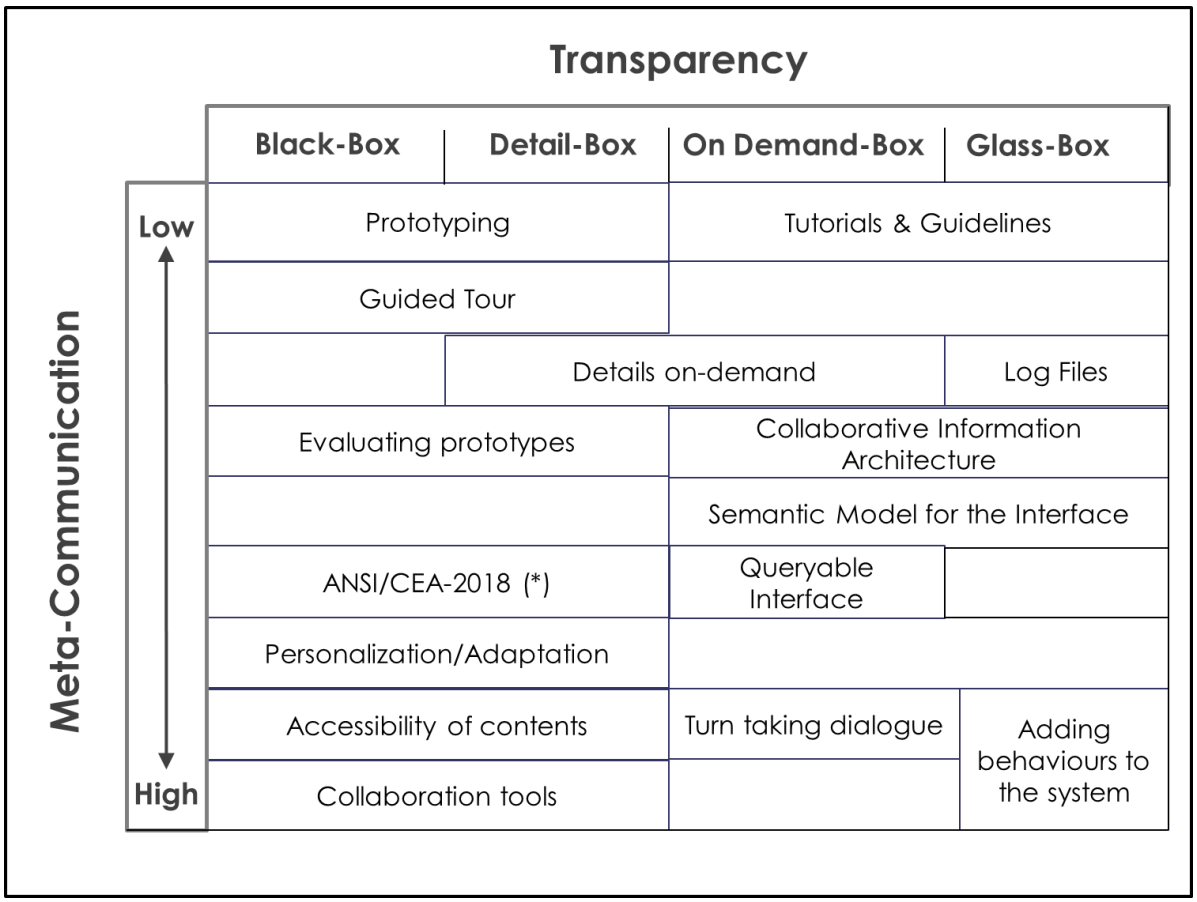

Figure 1. The Transmeta Design matrix shows Transparency and Meta-Communication dimensions. The matrix shows examples of specific implementations of Web services features. (*)ANSI/CEA-2018 defines an XML-based language for task model descriptions.

matrix in Figure 1 we identified specific strategies for implementing transparency and meta-communication features depending on the users' involvement. For instance, if the Web service allows a low participation of users, e.g., system-to-system data integration, the designer does not expose details about service functionalities to the users (black-box transparency) and does not involve the users in the design process (low user involvement). If the Web service admits a relevant participation of users, the designer provides the adequate tools and details in order to let users adjust the system behaviour (glass-box transparency) and thus the user involvement in the design process is high.

All the specific features listed in Figure 1 can be implemented as a common approach, the Transmeta Design, for designing Web services and improve usability. In particular, transparency and meta-communication features can be added

5. Web services architecture and design

The vast majority of Web services available today are based on distributed multi-tiered architectures [6]. Following this distributed multi-tiered model, Web applications are separated into three components, each one belonging to a different location in the architecture: the client, the enterprise server, and the database or legacy at the back end. For instance, there are, generally, three different kinds of components for managing the interaction between the enterprise server and the Web client: 1) session oriented services, 2) persistent data services, and 3) message based services. These components differ for the management of client data.

In a session-oriented service, when the client finishes its execution, the session and its data are released and deleted (e.g. private e-mail or

banking account). With a persistent data service collects data about the client, these are stored in one row of a database table (e.g. e-commerce Web sites). A message based service combines features of a session service with a message listener, allowing a Web service to receive client messages asynchronously (e.g. forums or e-mail).

For each one of these kinds of services, we can image situations in which users could feel uncertain about the final result of their actions. For example, if a session expires in an unexpected way, the user must know what is going to happen to her information. The answer differs depending on the type of services: a session oriented one will lose the inserted information, while a persistent data service will allow users to reconnect and recover their data. For instance by using the Transmeta Design matrix (Figure 1) and wanting to provide glass box transparency with an average user involvement, the Web service can be designed to display a log file with details about the particular service and performed actions, e.g. notify to user that data have been saved on a database in case of persistent service.

In the next section we present three examples of how it is possible to enhance the usability of a Web service adding transparency and meta-communication through ad-hoc features.

6. Using Transmeta Design with Web services

Consider the process of booking a flight. Nowadays, very often, we book our flight tickets by ourselves using travel-oriented Web sites. When we book and purchase a flight ticket we usually pass through different Web services whose purpose is: to provide flight search, to ask personal and credit card information, to manage dynamic information on flight schedule changes or interactions with the bank for money transactions. Including a transparency and meta-communication layer, for assisting and mediating the communication with the final user during booking and purchasing processes, can be crucial to provide a satisfactory experience with the Web site.

For instance, an airline flight search service is usually based on a session oriented Web service. In fact when we search for a flight and we experience a problem, e.g. networking issues, the Web session expires and we are requested to redo the search. This kind of Web services are, generally, implemented with the idea that other people are booking tickets while we are, and availability and dates may change in few minutes. In order to improve the usability and user experience more in general, we can report this information to the user (glass-box transparency) by using an understandable semantics (by designing for effective meta-communication). Referring to the Transmeta Design matrix (Figure 1), a possible solution is to implement a logging mechanism, for example display a small clock widget close to the submit button changing the colour of the button while the session (e.g. the duration) is about to expire. We may employ green, yellow and red, the traffic lights colour code, to show the session status with respect to session duration. With this information in mind the user will understand why the session expired and why she is requested to reintroduce data, or may take the correct actions to accomplish the process before session expires, e.g. ignore an incoming phone call.

Another interesting case happens when inserting credit card data. Many users assume that it will be permanently stored on the Web site delivering the service, but this is actually unclear. There are Web sites storing credit card information and associating them to the users' personal data and others that are not. When purchasing an airline ticket online, credit card data should not only be safely managed but accompanied with information on how and if it will be saved by using a turn-taking dialogue model (high user involvement). This can be augmented by providing another kind of logging mechanism: for example, a text panel including information on specific laws and informing the user that the password used for storing personal data should be of stronger type than usual (e.g. be at least fourteen characters long, contain both uppercase and lowercase letters, contain numbers, etc.). In this way the user can be aware that, not only personal data, but also credit card information depends on the strength of the chosen password and the Web service can provide a more reliable and effective user experience (i.e. Web services for credit card information like PayPal).

The last case we are going to consider for improving the usability of airline tickets purchase is related to message oriented services. When purchasing online tickets the user is subscribed (generally by her e-mail address) to systems' queues (banking, airline, etc.) that manage communications like sending the receipt

of the payment or notifying changes in flight scheduling. The user should be informed of the kind of information that is going to be sent to her within a scheduled timeframe; moreover informing that if she does not receive any information within such timeframe she should ask for it would be important. In this case, we can think to a logging mechanism in form of a small envelope icon, close to the selection box labelled "send me a receipt" where, by mousing over, it can display a message like: "notification will be sent within 72 hours". Furthermore guidelines can be explained to show how to proceed in case of missing e-mail confirmation. In this way the user will be aware that such service will not respond immediately but will notify information later, improving usability and the overall user experience with that specific Web service. These examples for flight booking and purchasing show how our Transmeta Design approach can be used to improve usability of Web services by adding specific features derived from the Transmeta Design matrix.

7. Conclusion and Future Works

In this paper, we presented an approach, called Transmeta Design derived from four main interaction design theories. In particular, we have considered theories such as *User-Centred Design*, *Participatory Design*, *Meta-Design* and *Semiotic Engineering*. These theories share common aspects, like the central role of the user and a similar design approach. Moreover, from the analysis of sample applications we have shown that characteristics of different design processes can be related to two common dimensions: transparency and meta-communication. We have identified a common approach among interaction design theories categorizing them through these dimensions, the Transmeta Design approach. The proposed approach, codified in the Transmeta Design matrix presented in section 4, fosters the use of specific features to enhance Web services usability. The proposed functionalities, extracted from the Transmeta Design matrix can be enriched or specified depending on the domain of application. For example, in the travel-oriented scenario, the clock widget has been chosen considering the particular domain and the problem to solve. We plan to extend our strategy to real cases adapting it to different domain specific scenarios.

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