Mastering ERP Interface Complexity
A Scalable User Interface Concept for ERP Systems

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Abstract: In recent literature, numerous research efforts addressed the usability of enterprise resource planning (ERP) systems. Although several heuristics, surveys and interviews provided valuable results to understand and improve the user satisfaction of ERP, explicit research on the user interface design has been rarely discussed. As ERP systems have a high dissemination in many enterprise areas, usability issues located in the user interface have a significant impact on millions of users. This paper gives an overview of the related work in the fields of usability studies, complexity reduction strategies and visual information presentation in ERP systems. The conclusion reveals a niche currently not considered in research. Therefore, an abstract interface model is introduced that aims to establish a new understanding of accessing ERP systems. The scalable user interface concept attempts to reduce the problem of user guidance and overall system complexity to ease the user's system access.

1 INTRODUCTION

Latest research in the field of enterprise resource planning (ERP) has primarily focused on technologies and concepts to keep up with a steadily increasing complexity of business processes and the volatile market needs. Examples of these technological improvements are performance optimizations basing on in-memory and multi-core computing (Tertilt and Krcmar, 2011), service-oriented architectures (Seth et al., 2011) or cloud-based business applications (Ragusa and Puliafito, 2011). In contrast to this technology-focused research and development, innovation concerning human-computer interaction in ERP is available, but obviously less considered. Whereas numerous research papers in the field of user satisfaction and usability have focused on the participation of users in the implementation process, top management support, self-efficacy or perceived usefulness of the system (Bin et al., 2010); (Mitakos et al., 2011), the dedicated investigation of usability barriers located in the graphical user interface (UI) is rarely discussed.

This paper addresses an elementary niche in human-computer interaction in ERP systems. The authors argue that traditional user interface concepts, which can be found in most state-of-the-art ERP systems today, cannot keep up with the rising requirements. Besides the evolution of business processes such as real-time supply chains and the related technologies described before, also the user's expectation of visualization and interaction concepts will significantly change. Nowadays, most users are already familiar with mobile, multi-touch and visually rich interfaces that they often use in their sparse time (e.g. entertainment systems in cars, smartphones and tablet-PCs, interactive displays in museums and exhibitions, gesture control in games etc.). In contrast, the majority of current ERP systems is still dealing with user interfaces that were established in the middle of the 1990's and utilize forms, tables, standard diagrams and mouse and keyboard interaction. (cp. (SAP AG, 2012)) Due to this essential gap between the high requirements and user expectations on the one hand, and the restricted UI capabilities on the other hand, users are rather forced to focus on usability problems than on fulfilling their actual tasks. (Singh and Wesson, 2009) In consideration of future trends in ERP UI design, the focus will be laid on web technologies, social media integration, interactivity and the differentiation between devices (stationary and mobile) and user profiles (casual, professional).

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(Falk, 2012) Therefore, the web-enabled service orientation will proceed and offers several potentials. The following section presents related work in the field of user interface design in ERP systems and highlights the achievements made so far. It examines the evolved understanding of the term *user satisfaction* within the last years, strategies to cope with ERP complexity and takes a look at the role of visual information presentation in ERP. Herein, also usability related user studies are addressed. The following section 3 presents our motivation for a paradigm change in the UI design of ERP systems. The concluding section 4 introduces an abstract interface model for ERP systems and thereby incorporates the prior findings. Section 5 summarizes this paper and gives a brief view on our future work.

2 RELATED WORK

This section on related work presents research literature from three relevant fields. The first part is devoted to related studies on user satisfaction and usability in the field of ERP. This section presents chosen definitions of the term *user satisfaction* and highlights the insufficient consideration of the graphical user interface. Furthermore, it describes prior results from a usability study on manufacturing enterprises, which was conducted by the authors in 2011. In the second part, strategies to reduce ERP complexity, such as adaptive UIs and user guidance, are addressed. These concepts intend assisting the user in accomplishing his or her current task by utilizing several supporting strategies. The third part gives a brief summary of visual information presentation in the field of ERP, which "*seeks to provide people with better and more effective ways to understand and analyse these large data sets, while also enabling them to act upon their findings immediately*". (Keim et al. (eds.), 2010)

The abstract interface model, which is described in section 4, comprises the presented concepts of user guidance and advanced visualizations to decrease existing usability problems.

2.1 Usability and User Satisfaction

In recent literature, user satisfaction is often referred to as one of the main user-centered critical success factors of an ERP system. However, its definition is manifold. Especially the aspects influencing user satisfaction vary widely from organizational to human aspects. In this section, several occurrences of the term and their meanings are discussed to illustrate the little consideration of the graphical user interface.

The term *user satisfaction* can be often found in ERP market surveys. This type of survey benchmarks available (and mostly commercial) products to support the selection of an ERP system according to several criteria. Whereas *"...Functionality is still the most important selection criterion..."* for an ERP system (Intelligent systems solutions GmbH, 2011), user-centered factors are getting parenthetically summarized to the aspect of *ergonomics*. The ergonomical criterion is ranked fifth in the list of selection criteria, whereas it is not even mentioned in the list of reasons for implementing a new ERP installation. In contrast, further objectives pursued with an ERP implementation project, such as faster access to enterprise information, indicate the implicit necessity of user interface concerns besides the well discussed performance issues.

An organizational perspective on the term *user satisfaction* can be found when it comes to the implementation and usage of an ERP system. Next to user-centered factors, such as self-efficacy, experience and perceived usefulness (Mitakos et al., 2011), additionally the corporate culture, top management support (Bin et al., 2010), position in organizational hierarchy and user participation in the implementation process (Zviran et al., 2005) are just as well considered to influence user satisfaction. User interface aspects are not explicitly declared as a factor that has impact on user satisfaction.

During the system usage, also UI related considerations on cognitive and dialog factors emerge. Next to the aspects stated above, the term is now enriched by navigation, user guidance, visual factors, minimal memory load and learnability (Calisir and Calisir, 2004); (Ozen and Basoglu, 2006). Several years ago, (Topi *et al.*, 2005) interviewed ERP users to identify critical deficiencies in their system usage. Major difficulties existed in the identification of and the access to the right functionality, support in transaction execution, system output limitations, terminology and finally the overall system complexity. Although the results originate from an interview with only ten participants, the results indicated concrete user interface deficiencies.

With the aim of identifying heuristics for ERP usability, (Singh and Wesson, 2009) classified many of the common usability criteria found in current research literature. Five major heuristics resulted, comprising navigation, learnability, task support,

presentation (input and output) and customization. Examples for potential usability issues assigned to the heuristic of *navigation* are "*Information is not easy to find*" and "*There is no form of guidance within the system to aid the user when completing a business process.*" Examples for potential usability issues assigned to the heuristic of *presentation* are "*Visual layout is too complex.*", "*Output is not easy to understand and interpret.*" and "*The UI of the system is not very intuitive.*" (Singh and Wesson, 2009)

In a preliminary and regional survey with 58 participants, we investigated ERP systems concerning the graphical user interface. The study was focused on small and medium sized enterprises (SME) in the manufacturing domain in an eastern part of Germany and was conducted in 2011. Whereas 70.0% of the interviewed participants attested a high functional satisfaction of their ERP system, significant potentials for improvements existed with respect to adequate information presentation. The available interfaces often do not meet the user's current needs for task-oriented views and an appropriate level of detail. Depending on the ERP system and business branch, various interface elements are available. Due to its versatility, the table is the most prevalent type to present information (90.9%), whereas form-like layouts were also found very frequently (81.8%). In contrast, topological and time-based visualizations such as floor plans and process views in terms of network diagrams as well as three-dimensional views have been significantly less mentioned. To gain a further insight into concrete UI requirements, the participants were given the choices described in table 1 below.

The survey revealed that a major problem can be seen in the task-oriented visualizations (75.0%). In comparison with the little availability of alternative visualizations in current ERP applications, this might be one of the reasons for the high responsiveness. The fixed presentation type of enterprise data seems to be insufficient to fulfill the user's need of changing the visualization type when necessary. Similar results have been observed for the paradigm of detail and overview (59.4%). Current ERP systems seem to support this aspect inappropriately, as they offer a fixed and quite detailed view on the enterprise data (e.g. in a table or form). These two usability problems of inappropriate visualization and level of detail have a significant impact on the graphical user interface. Furthermore, these problems directly affect accessing the enterprise information and therefore need special attention in future research. The remaining aspects of faceted browsing & semantic search (34.4%), 3D-views on processes and facilities (25.0%) and especially multi-touch devices (9.4%) received significantly less acceptance.

2.2 Reducing ERP Complexity

In current research, three main strategies for coping ERP complexity exist. The first approach is based on user guidance during a transaction by utilizing concepts such as recommending the next steps, auto-completion of input fields, highlighting mandatory content or displaying help instructions for error prevention and treatment. As the complexity remains constant in this case, the user is less confused and more confident because of the assistance in questions of interaction. In most cases, the assistance is implemented as an additional window or interface region on top of the underlying standard ERP system. A second strategy to cope with the complexity of ERP interfaces is the simplification of

Table 1: A brief description of the choices, which have been supposed to improve the UI and its usage.

Task-oriented Visualizations	The system offers several visualization types of a process or system state. Examples are listings (table), network diagrams and floor plans.
Detail and Overview	It is possible to adjust the level of detail from a fine-grained view to an aggregated overview and vice versa.
Faceted Browsing & Semantic Search	Input of letters or words results in a listing of semantic or textual equivalent items found in the system. The concept of faceted browsing allows for refining the results (by category, date, department, priority...)
3D-Views on Processes and Facilities	Current and upcoming system states and processes are illustrated with the help of 3D-visualizations. Examples for such process information are fill levels, durations, downtimes and alert situations.
Multi-touch Devices	System interaction is supported by touch-sensitive and sensor-equipped devices. The interaction supports multiple inputs.

the displayed content itself. This strategy reduces the UI functionality according to the user role or other context information. In this case, the guidance is not explicitly focused but the complexity is reduced to an amount that the user is able to understand. The third strategy is based on similarity and utilizes well known patterns that the user knows from different standard applications or other domains.

Although these strategies are very powerful in reducing ERP interface complexity, they can only make a contribution to minimize the user's time spent on learning how to transfer his or her domain and process knowledge to the ERP system. As most of the training time is caused by exactly this mapping from domain knowledge to transaction identification and execution, the reduction of ERP interface complexity is an essential precondition for intuitive ERP systems.

2.2.1 User Guidance

A first example of user guidance is the adaptive navigation support (ANS) introduced by (Supulniece, 2012). The proposed ANS meta-model complements existing models for the development of user adaptive enterprise applications (UAEA). Therefore, it comprises several sub-models to describe the end-user, his or her goals and expectations, the changing object (trigger of adaptation), the adapted object itself +and the adaptation algorithm. The supporting capabilities address a broad scope which covers process execution overview, navigation, information, problem prevention and error handling. The ANS recommendation system resides next to the standard functionality in the UI of an ERP and offers links to recommended next steps, mandatory activities or already executed forms.

A second example of user guidance is the history-based playback mechanism from (Babaian and Lucas, 2012). Assuming that available help mechanisms in ERP systems are too generic for concrete user questions regarding enterprise-specific interaction issues, a log-based playback mechanism is proposed. The prototype replays interaction sequences in real-time according to previously generated usage log data. This approach results in a more flexible and low-cost alternative to pre-recorded and generic tutorials or other types of support.

2.2.2 Content Simplification

Decreasing the complexity by reducing the content of a system's interface, such as masking irrelevant form fields or offering limited functionality according to context information, is a second major strategy to handle ERP complexity. In their research on ephemeral adaptation for ERP menus, (Findlater et al., 2009) follow the approach of content reduction by gradually fading-in menu items, which are predicted to be less important. In contrast, most important entries are presented right from the beginning. By gradually revealing the variety of available items, the user is enabled to easily identify the high priority functionality immediately. In particular, this approach involves a temporal dimension to reduce the user's cognitive workload.

Investigations regarding the complexity of an ERP system interface have been recently undertaken by (Parks, 2012). Substituting an existing standard ERP UI, a simpler version has been designed to compare the effects on task success and time consumption with the traditional user interface. With the help of an inventory use case, the authors discussed the question: "*What impact does the complexity of ERP interfaces have on end-user success and task time while completing a transaction?*" The results for this distinct use case stated that "*complexity was a significant variable only for time spent working on the task, not success*" (Parks, 2012)

2.2.3 Similarity

The concept of similarity uses well known or de-facto standards to familiarize the user with the (probably new or rarely used) ERP system. The interface has to be at least partially adapted from another application that most users already learned to use. The similarity might cover the visual appearance, grouping of functionality or the procedure to execute a distinct functionality. One example for this strategy is Microsoft Dynamics™ which uses the appearance of the Office Suite (Microsoft Corporation, 2013), which many users are familiar with.

2.3 Visual Information Presentation in Enterprise Applications

In (Parush et al., 2007), the hypothesis has been corroborated, that "*graphical visualization can improve the performance of the human operator using ERP systems for supply chain management*". Therefore, the original display design of a commercial ERP system has been compared with a prototype which offered radial hyperbolic tree and tree map visualizations next to the standard table

form. Although the findings date back to 2007, they revealed, that for "*experienced and inexperienced users, hyperbolic tree and tree maps graphical visualizations improved performance*". These results indicated promising potentials of visual information presentation in native ERP environments.

Pioneering research in the field of visual analytics has been done by (Card et al., 1999, p.6), who classified user objectives into *exploration*, *discovery*, *explanation* and *decision making*. (Yi et al., 2007) complemented this research by introducing primary interactions on information sets such as *filter*, *connect*, *select*, *reconfigure*, *encode* or *detail*. The domain of visual analytics is already an important part of distinct enterprise applications and in particular in the field of Business Intelligence (BI). Especially for the domain of BI, several solutions exist, which offer innovative visualizations and direct interaction. (Tableau Software, 2012) However, (Wang et al., 2011) state that "*most domain analytical practices generally vary from organization to organization. This leads to diverse designs of visual analytics systems in incorporating domain analytical processes, making it difficult to generalize the success from one domain to another.*" This problem is addressed by their proposed design framework for visual analytics systems in organizational environments. Herein, the *Design Artifacts Specification* is also facilitated which consists of visualization and interaction combinations.

3 MOTIVATION FOR A PARADIGM CHANGE

The non-exhaustive overview of related work intended to briefly present relevant fields of ERP UI research. It discussed strategies to reduce the interface complexity as well as research on visual information presentation. On the one hand, it can be concluded that many efforts have been done to guide the user through his or her current transaction and to avoid handling errors. On the other hand, visual and interactive information presentation is already an essential part of specific enterprise applications (such as BI), although it is not an essential "core feature" of standard ERP systems.

The section on user satisfaction and usability revealed, that the *overall system complexity*, *user guidance*, *identification of and the access to the right functionality*, *availability of task-oriented visualizations* and *detail and overview* are essential user interface challenges in ERP today. The subsequent presentation of strategies to cope with the interface complexity as well as the visual information presentation already addressed these deficiencies and proposed promising solutions. However, the authors argue that there is still a niche which has not been investigated so far. Whereas user guidance as well as visual information presentation are considered side by side in current research, the conjunction of both strategies is not addressed. Since both aim at reducing complexity and offer a more intuitive and friction-free system access, their conjunction could lead to an even better UI design. The following section discusses two barriers in current ERP interface design, which motivate the establishment of the abstract interface model presented in section 4.

A first major barrier can be seen in the absence of a navigation guide, which not only leads the user from one sequential transaction step to the next, but also from an initial overview to the final place of editing and execution. As introduced by (Shneiderman, 1998), this navigation path covers "*Overview first, zoom and filter, then details on demand.*" This visual information seeking mantra has not been applied to standard ERP systems so far, and results in very limited capabilities to adjust the level of detail. The adaptation of the level of detail and therefore the adjustment of complexity is one of the user needs identified in section 2.1. Hence, current systems seem to lack a hierarchical user interface guide, which actively supports the navigation from overview to detail and vice versa. This guide has to utilize mechanisms such as abstraction, aggregation and reduction to achieve orientation as well as detailing and selection to achieve editing and execution.

A second barrier can be seen in the limited set of available visualizations (see "layouts" and "UI controls" in (Blankenship, 2008) as an example). Current ERP systems rely on tables, lists, tree and context menus, forms and standard diagrams. While tables and forms are extremely appropriate to visualize explicit values and to allow for quick editing, they have limited capabilities to illustrate complex processes, correlations, consequences, dependencies, states or other types of implicit information. "*In general, since data in ERP systems is highly structured, it lends itself to be presented better graphically.*" (Parush et al., 2007) In consideration of the huge variety of visualization types known in other domains today (cp. (Lima, 2012)), the limited set of UI elements in ERP systems is insufficient. Furthermore, existing and classifying databases for visualizations could be

easily used to obtain appropriate and task-oriented interface elements with ease (e.g. (Keck et al., 2011)). Therefore, current ERP systems seem to lack extended visualization capabilities, since most of the available screens are too detailed, inflexible and utilize only a fractional amount of current UI potentials.

The authors assume, that existing usability problems are significantly related to the user interface and especially to these two barriers. Nowadays, users are already familiar with innovative devices and applications in their spare time, which offer rich visualization and interaction capabilities. In contrast, users are facing complex, inflexible and often outdated UIs at work. The hierarchical assistance in the form of an adaptive and scalable user interface to adjust the level of detail as well as the involvement of appropriate visualizations to compare, explore and process enterprise information could be able to overcome current deficiencies.

4 TOWARDS AN ABSTRACT INTERFACE MODEL

Examining the UI structure of ERP systems from an interface designer's point of view, common patterns emerge. While most ERP systems seem to appear quite different at first sight, commonalities in the user objectives and the corresponding visual modality become apparent. The user objectives can be classified into three abstraction layers, reaching from *orientation and overview* to *search and filter* and finally ending up in *editing and execution*. While the first layer gives an overview of available functional categories of the system, the second layer is focussing on a distinct information subset (e.g. ERP modules for production, finance or customer). Herein, the set of domain items can be textually searched and filtered to identify an item or subset of interest. The third layer is even more tailored according to a selected business item type and allows for editing the object's properties and status parameters.

4.1 Visual Modalities

Visual modalities present the enterprise information in a distinct manner and are related to one of the user's objective layers described above. The first visual modality, which corresponds to the objective of *orientation and overview,* offers access to a functional category primarily in the form of a *list*, *tree*, or *(hierarchical) menu*. By selecting one of the items herein, the user accesses the second layer and its visual modality. This layer presents the desired domain content (e.g. production orders) for the user objective *search and filter*. As one of the most generic visualizations, this second layer uses mostly *tables* to present the items in rows and their properties in columns. In addition, textual search and filter mechanisms assist the user in finding the right business item(s). By selecting one of these items, the third layer and its visual modality will be entered and enables the user to view and edit all item and status parameters in a *form*.

Summarizing, the characteristics of the three Layers are evolving from the user's intention of *orientation* to the intention of *execution*. Figure 1 summarizes the findings and illustrates the proposed abstract interface model. It relates the abstract user objectives and interactions from (Card et al., 1999,

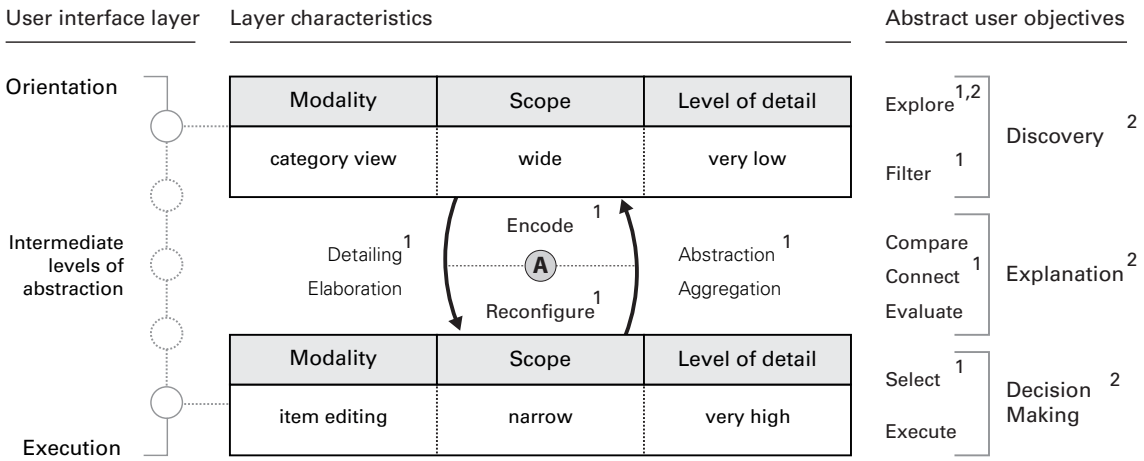

Figure 1: Proposed abstract user interface model covering the levels of abstraction (left), the related user interactions from (Yi et al., 2007)[1] and abstract user objectives from (Card et al., 1999, p.6).[2]

p.6)and (Yi et al., 2007) presented in section 3 to the proposed UI layers. The characteristics of these layers are described by the modality, the scope of the information and its level of detail. The main concept aims to pick up the user by a general and less complex interface to ease the initial system access. After the user has been familiarized with the available categories, a drill-down is executed to reveal additional, but more specific items and operations. The authors assume, that the appliance of mechanisms such as detailing and abstraction, and especially the encoding and reconfiguring based on innovative visualization types are suitable to cope with the complexity of current ERP systems (see Figure 1, A). The adaptation mechanism addresses the content, appearance, amount and composition of the ERP information. According to (Yi et al., 2007), the interaction across the diverse layers covers:

- Select: mark something as interesting
- Explore: show me something else
- Reconfigure: show me a different arrangement
- Encode: show me a different representation
- Abstract/Elaborate: show me more or less detail
- Filter: show me something conditionally
- Connect: show me related items

Hence, the authors propose to extend the meanings of UI adaptation beyond the concepts discussed in section 2.2, which was focused on dialog-based user guidance, content reduction and similarity. Whereas concepts in the related work addressed the adaptation of the content by manipulating the amount of interface items, also the adaptation of the appearance and its composition should be considered.

5 SUMMARY & FUTURE WORK

This paper argued a niche in usability research of ERP systems regarding the graphical user interface. The enormous number of industry branches and users that are affected by usability problems has motivated the further research in this paper. Selected understandings of the term *user satisfaction* were presented and the subsequent section highlighted concrete usability problems in the field of ERP. The section "Reducing ERP complexity" presented promising solutions to cope with the complexity of ERP user interfaces. The subsequent abstract interface model addressed two barriers in current ERP UI design, namely the hierarchical user interface guide (from overview to execution) and enhanced visualization capabilities (esp. the appliance of rich visual interfaces adapted from related fields such as information visualization and visual analytics). This research is not fully accomplished and therefore cannot present a proof of concept yet. As further research is required, it will focus on the intuitive implementation of the "vertical" UI guide and the identification of appropriate visualizations to bridge the gap between the layer of *overview* and the layer of *detail*. Finally, it can be concluded, that future ERP systems could offer two major improvements related to the user interface:

- Offering a hierarchical ("vertical") UI guide besides existing guidance approaches (for "horizontal" dialog steps). Especially untrained users are uncertain about available functionality and face a level of detail that might be too high for their current objective. By offering a simplified and aggregated entry point to the system, which extends and concretizes its features, users are enabled to discover the subsequent (and more detailed) layers on their own.
- Extending the visual capabilities and enhance the appropriateness for complex correlations of ERP information. Experienced users who are aware of the underlying business processes are concluding decisions based on their knowledge and mental model. Especially untrained users are often unaware of potential side-effects which might result in operating errors and uncertainty. The mapping of the user's process and domain knowledge to system operations and information can be enhanced by the utilization of innovative and up-to-date visualization and interaction techniques.

To achieve these ambitious goals, a prototypical framework has been designed which is based on the Silverlight/ .NET platform and programmed in C#. It allows for the definition of the scalable user interface and comprises the specification of layers, their type of visual content (table, map, circular diagram etc.) and the transitions between these layers (esp. semantic changes). The data can be acquired from several types of data source and combined according to defined join operations. With the help of an editor, the visualization and data layers are mapped on each other to specify the final user interface and its composition, behavior and appearance.

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