

Modernizing Exploration and Navigation in Enterprise Systems with Interactive Visualizations

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Abstract. Enterprise Resource Planning (ERP) systems empower employees with access to vast amounts of data from across the organization. Learning how to navigate an enterprise system and explore the data within, however, can require herculean effort. Despite the efficacy of visualizations for enhancing knowledge discovery and exploration, they have yet to be applied to assisting users of ERP systems. In this paper, we present two visualization components designed specifically for those users. The first provides an easy-to-use search interface for visualizing relationships between data entities, while the second supports navigation via an interactive map. Both have been implemented in a prototype for validation in future studies.

Keywords: Interactive visualizations · Dynamic visualizations · Enterprise systems · ERP

1 Introduction

Contemporary visualization tools and techniques have been widely applied to visualizing data in various contexts. One domain in which they have not yet found broad applicability, however, is in Enterprise Resource Planning (ERP) systems, which integrate and manage data and processes from across the organization. While process visualizations have been applied to the off-line management of business workflows [14] and to navigating process repositories [5], they have not been integrated into leading ERP systems for assisting users of their notoriously difficult-to-use interfaces. The acknowledged usability issues users experience are in no small part due to the limited views provided of the underlying data and relationships, the overly complex menus used for navigation, and the lack of transparency concerning the processes being supported [1, 6, 7].

The primary contribution of the research presented here is in providing alternative means by which users can explore and navigate the transaction- and process-related data and relationships underlying ERP systems, which is typically presented to the user in the form of tables and lists. As noted by Shneiderman [2], effective visualizations contribute to the users' understanding of their data and support the discovery of relationships that would otherwise be difficult to perceive. These findings were recently

confirmed in studies specifically addressing ERP systems and tasks [6, 7, 9]. Our goal is to bring these benefits to enterprise system users by modernizing ERP interfaces with interactive visualizations.

In this paper, we present two types of visualization components for enterprise systems. These two visualizations address two different problems that users often experience: identifying data items related via complex many-to-many relationships and locating the correct functionality within the system. The first component, called an Association Map (AM), highlights associative relationships between the entities used in performing business transactions. Users are able to explore these relationships and perform selections of relevant data elements. The second component provides a novel means for task navigation via an interactive graph called a Dynamic Task Map (DTM). DTM is based on the transaction records derived from an SAP ERP system. It visualizes several measures that reflect aggregate user activity, thus depicting common usage patterns. Each of these components was implemented in D3 (see <http://d3js.org>). The utility and effectiveness of the developed approaches will need to be validated with user studies, which are planned for the future.

2 Related Work

The difficulties that ERP system users face in operating these complex data-based systems have been investigated and documented by several researchers. Topi and colleagues [13] first reported on a field study that included in-depth interviews of 10 users of a major commercial ERP system. Usability issues discovered from the analysis of the reported user experiences with the system were categorized according to a framework based on the system-user collaboration paradigm of human-computer interaction. These categories included identification of and access to the correct functionality, transaction execution support, system output limitations, support in error situations, terminology problems, and overall system complexity. Several of these problem classes have been confirmed later by different researchers using a variety of methodologies and examining a wider range of ERP systems [10, 11, 7]. Most recently, Lambeck and colleagues [7] conducted a survey of 184 users of different experience levels using a variety of ERP systems and confirmed that many of the identified problems still persist. Particularly relevant to the work presented here, this survey revealed that the “ability to locate desired enterprise functionality remains a general usability problem across different levels of experience” and that the “availability of useful visualizations improves perception of complexity” reported by the users.

There are fewer studies that attempt to create visualizations and other types of design interventions and investigate their efficacy in making ERP systems more usable [2, 4, 8]. In particular, Parush et al. [9] have performed an experiment with 85 users in which they compared user performance of ERP tasks of varying complexity in two different environments. In the first environment, system data was presented in a typical, tabular form, and in the second, the data was presented using visualizations. Two different types of visual displays were used for two different purposes: a Radial Hyperbolic Tree for depicting hierarchical data, and a Treemap showing quantitative

data as bars for easy visual comparison. The findings of the experiment were that visualizations had a positive impact on the completion time for all task difficulty levels, with a greater impact on the more complex types of problems. Novice users benefitted more from the visual approach in this study, although in the aforementioned survey-based study by Lambeck and colleagues [7], the importance of visualizations was ranked similarly by novice and experienced users.

The same survey [7] also examined users' perceptions of navigational tools within ERPs. It revealed that users prefer in-context menus, i.e., those that provide access to a subset of tasks closely related to the currently performed task, to the tree-like ones, which present the overall task hierarchy regardless of the task in which the user is currently engaged.

A different stream of research, focused on business process mining [14, 15] and process visualization languages [3, 5], is also related to the problems of guiding the users through the "maze" of ERP screens. Process mining is concerned with identifying common paths through the system as manifested by users. Researchers have proposed using information on the commonly occurring task sequences discovered via mining to aid the users in selecting the next task, thus reducing navigational complexity by using a visual representation of business processes and common task transitions. The problem is exacerbated by the fact that business processes and, correspondingly, the visual languages used to represent them, are very complex, since they include a lot of details. Detailed information is needed to capture a variety of scenarios, yet an individual user typically needs to be aware of only a subset of the details surrounding the tasks he/she performs.

Creating a visual representation that can be quickly adapted to the required level of detail and is well suited to a user in a particular role [3] is the subject of ongoing research. Furthermore, Hipp et al. [6] describe Compass - a software system that allows navigation in a collection of process models and corresponding external information. In an experimental user study, subjects using a version of the system enhanced with a variety of dynamic, interactive, multidimensional visualizations reacted positively to it, showed a slightly better performance in terms of time, and made significantly fewer mistakes than those who used a similar system without the added visualizations.

There is a growing body of research that suggests the need for developing visualizations for complex data and navigational tasks within enterprise systems. We explore such visualizations in the remainder of this paper.

3 Visual Explorations of Master Data and Transactions

In this section, we present two visualization components developed for assisting users of ERP systems. We first describe the Association Map (AM) component, which offers various visualizations for discovering the relationships between associated data elements. The second component, the Dynamic Task Map (DTM), provides a novel means for supporting system navigation by providing interactive visualizations of the transactions performed by the system's users.

3.1 Association Map (AM)

The database at the heart of an ERP system stores vast amounts of data from across the enterprise. Knowledgeable users with sufficient expertise can pull the relevant information related to any transaction performed by the system. The learning curve for gaining that expertise is a very steep one, however, and even the most experienced users need to refresh themselves on the steps to take for performing tasks and running reports they don't access on a regular basis. Most users will only learn the small portion of the system that relates to their everyday tasks. Training focuses on step-by-step instructions concerning which transactions to access and what data to enter. The higher-level understanding of how tasks and data elements are related is often lost in the minutiae.

The Association Map (AM) visualizations presented here provide any user with a simple means for exploring the relationships between data elements. They offer a view of the data that is not readily evident from detailed reports and support the analysis and interpretation of the underlying, detailed data. An example of such data is shown in Fig. 1, which provides a view of purchasing documents for a particular vendor in an SAP ERP system. A vendor can supply one or more types of material that are maintained by one or more plants, and each material can be supplied by one or more vendors. From the report shown here, it is possible to pull out the materials supplied by a specified vendor and the plants that maintain them (the first two records in this report show that Vendor 101000 supplies Off Road Helmets and Road Helmets that are maintained in plant N00). Aggregating this data into a higher-level format highlighting all materials supplied by a particular vendor and maintained in a particular plant would typically involve a third party tool, such as a spreadsheet, or the creation of a customized report.

Vendor 101000 Olympic Protective Gear									
Material	Material Short Text				Info Rec.		De		
P.Org	InfoCat	Plnt	PGp	Plan	Time	Minimum	Qty	Un	Var
Price	Origin	Net Price	Currency	Qty	Un	Document	Item	Q	
OHMT1000	Off Road Helmet				5300000000				
<input type="checkbox"/>	US00	Standard	N00	1	Days	0	EA		
Condition		No Price Found							
Pur. Order	25.00	USD	1	EA	4500000000	00010	06/30/20		
RHMT1000	Road Helmet				5300000001				
<input type="checkbox"/>	US00	Standard	N00	1	Days	0	EA		
Condition		No Price Found							

Fig. 1. SAP purchasing information records by vendor

The visualizations shown in Fig. 2 provide intuitive means for users to explore these types of higher-level relationships. While the related entities shown here are the plants, materials, and vendors used in the purchasing process, any entities in a many-to-many relationship could be visualized in the same ways.

Figure 2 shows the search interface. This visualization extends the D3 Concept Map (see <http://www.findtheconversation.com/concept-map>) by allowing the user to specify up to three search parameters. The light gray lines show all of the connections that exist in the data between the three entities.

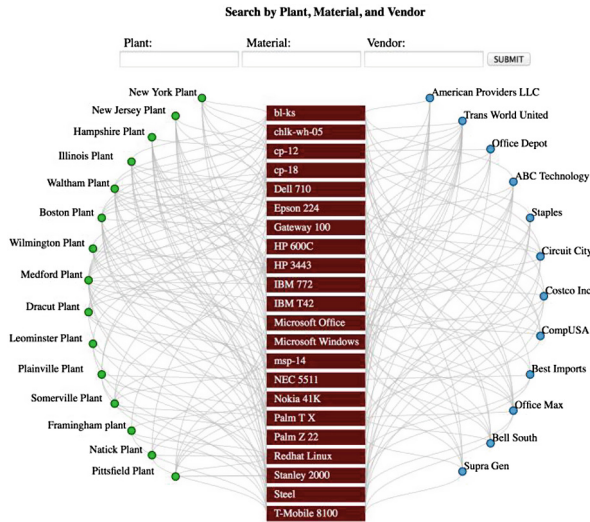


Fig. 2. Search interface for finding relationships between plants, materials, and vendors.

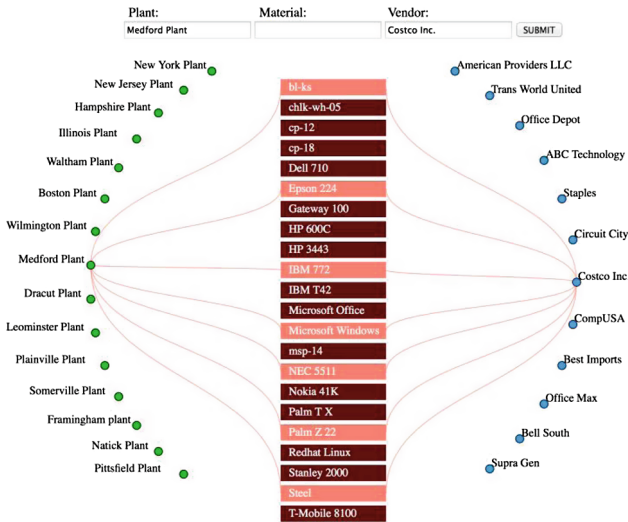


Fig. 3. Search by specific plant and vendor.

Figure 3 shows the results of a search in which the user has specified a plant and a vendor as search parameters. From this view, the user can easily see all of the materials maintained in the specified plant that have been supplied by the specified vendor.

This information can be helpful to a plant manager, for example, in analyzing vendor relationships.

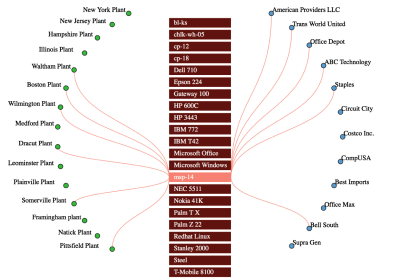


Fig. 4. Selection of material from map

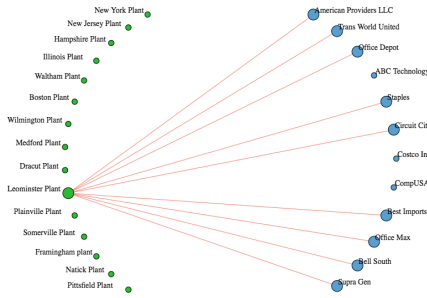


Fig. 5. Selection of plant from map

In Fig. 4, the user has clicked on a particular material in order to see all the vendors that supply that material and the plants where it is being maintained. This information is useful for a manager who is looking to consolidate inventory in fewer places or to find another plant that may be able to supply a particular material without having to order more from the vendor.

Figure 5 shows the visualization resulting from the user clicking on a particular plant, which reveals all of the vendors used by that plant. Similarly, the user could click on a vendor to show all of the plants with inventory supplied by that vendor. Both views support analysis of plant-vendor relations.

The information contained in all of these visualizations is available from ERP systems but, as noted above, it is likely to be presented in tables or reports with a degree of granularity similar to that shown in Fig. 1. While not part of the current implementation, the AM visualization component could be extended to allow the user to drill down from the higher level views shown in Fig. 2 to the detailed reporting data in Fig. 1.

3.2 Dynamic Task Map (DTM)

One of the difficulties most widely reported by enterprise system users concerns navigating to the desired task (a.k.a. transaction) interface. In addition, users, especially those new to the interface, often have trouble figuring out the next step; that is, what follows the task that they are performing. These difficulties stem from the sheer number of different functions implemented within an enterprise system and a general lack of guidance regarding the subset and sequence of transactions that form a specific business process.

The principal navigational tool in ERP systems is typically a menu structure. In addition to context-specific menus within each task interface, there is one main, all-encompassing expandable menu, which is displayed upon logging in and to which the user returns upon completion of a task to select the next one. Figures 6 and 7 present two views of the SAP main menu, which is called the Easy Access Menu. Figure 6 shows the full menu in its most compact, unexpanded form. Figure 7 shows the same menu with the Accounting branch partly expanded for accessing a specific task interface, such as Customer Sales. If the entire menu were to be expanded, it would take at least tens of pages to display. The nodes of the menu leading to a particular transaction can be up to seven levels deep in the hierarchy and are occasionally duplicated under different branches. The grouping of the transactions within menu branches is not always intuitive, even for expert users. It is not surprising that ordinary users experience difficulties and feel lost while looking for the right transaction using the menu, often giving up their search and turning to a colleague or to their notes for help [1, 13]. Users typically eventually learn to navigate to their most common transactions via an alphanumeric code, which they memorize or keep close by. Reliance on transaction codes, however, hinders users' independent exploration of the vast and powerful resources that the ERP system offers. The problem is exacerbated by the poor inter-task navigation options: when within a task interface, it is often difficult to locate the way to open a related task, such as when creating a new user account and needing to access an interface for testing it.

The SAP menu presented here is typical for the major vendors of ERP software. The menu structure can be configured to include a selection of favorite tasks and exclude entire categories for a specific user profile. Personalizing the menu mitigates navigation problems for some users; however, it does not alleviate them for those users who work with a relatively large set of ERP components. Nor does it help users in finding potentially useful parts of the system with which they are not familiar.

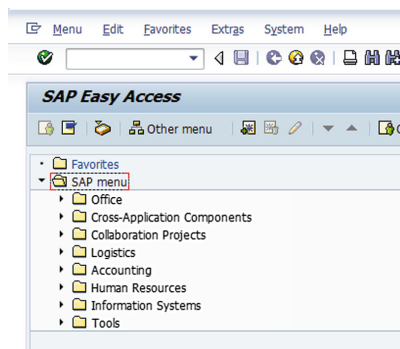


Fig. 6. SAP Easy Access Menu in its most collapsed form

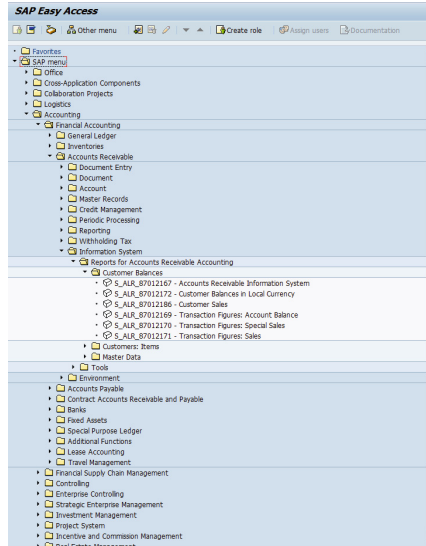


Fig. 7. SAP Menu expanded for selecting a Customer Sales transaction

Researchers have applied process mining and process modeling approaches that we reviewed earlier to discover and visualize the task chains that comprise business processes performed within a specific organization. While these approaches can be used to guide users, they do not solve the problem of navigation entirely, since even when the users know what they should do next, it is still difficult to find how to navigate to the specific transaction unless the code is known.

We have developed a prototype of an alternative navigational tool called Dynamic Task Map (DTM). DTM depicts ERP tasks as a set of circular nodes, each labeled with its task name (Fig. 8). The DTM is composed from the task usage history, which is documented in the ERP system log. The size of each task circle is proportional to the task's frequency of use. Tasks that were performed by a user close together in time are positioned closer together.

The graph changes when a user selects a transaction, as shown in Fig. 9. The visualization automatically zooms onto the selected task, which is shown with a larger title. The selected task and those transactions that commonly co-occur or follow it are linked together and highlighted in a shade of red, thus helping the user identify and navigate to a related transaction. The color intensity of a connected transaction indicates how likely it is to follow the selected one. The other transaction nodes and their labels are still visible but are de-emphasized using a lighter shade of blue.

The prototype implementation presented here, while based on real ERP usage data, does not provide access to the respective task interfaces within an ERP system. If built into a system, it could be used as a navigational tool. Currently, the prototype does not group task nodes according to any relationship other than co-occurrence with the selected task, but different types of groupings can be added to further enhance the map and provide additional guidance to the user regarding the available transactions.

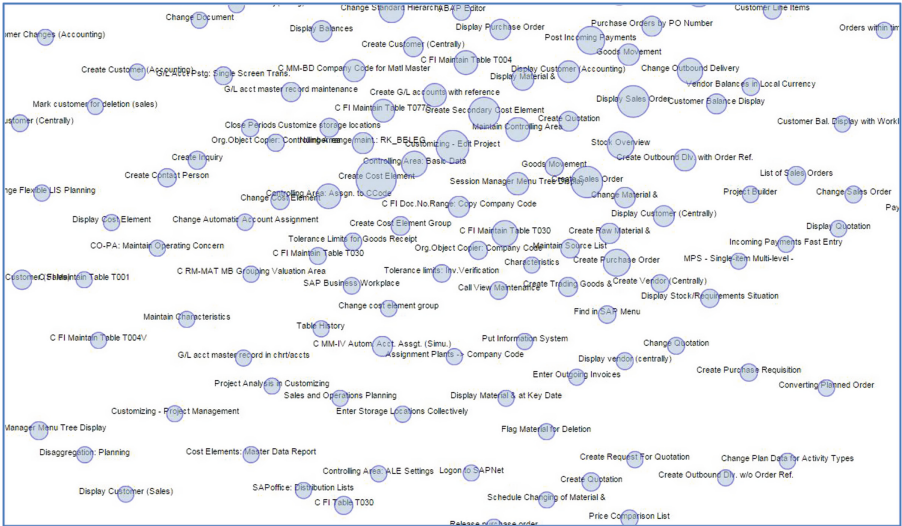


Fig. 8. Visualization of the complete list of transactions

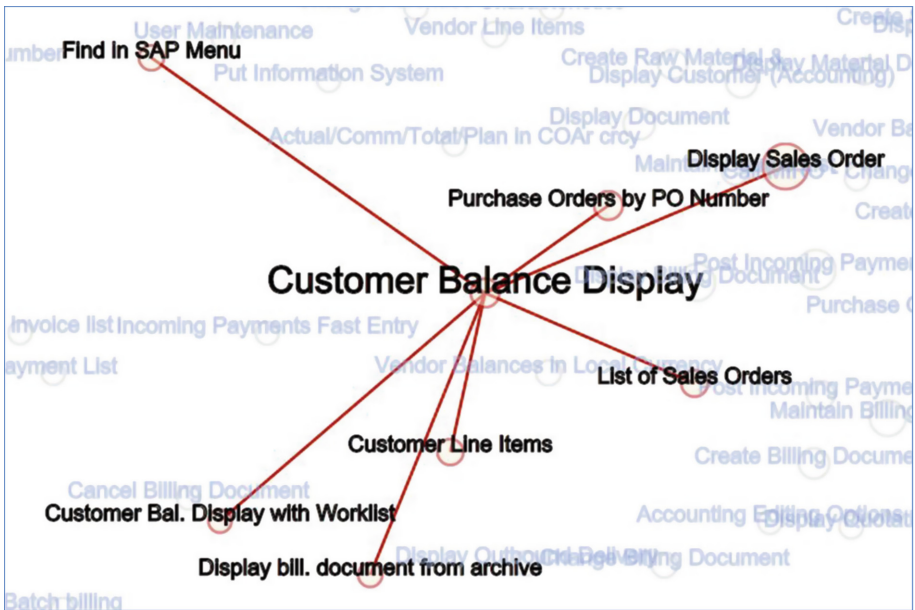


Fig. 9. Zoomed view, after the user has selected one of the nodes. The selected transaction node is shown with a larger title. The color of the connecting circle indicates the likelihood of transition to that transaction based on the past usage history.

4 Conclusions

In this paper, we have demonstrated the applicability of dynamic, interactive visualizations to guiding users in the ERP domain. These visualizations, which we have implemented using D3, address some of the difficulties users of these complex systems encounter, including insufficient means for data exploration, inadequate support for higher-level analysis, unwieldy menu structures that hinder navigation, and the lack of transparency concerning relationships between tasks.

The greatest limitation of the implementation we reported on here is that it is based on a relatively small data set compared to a significantly larger one that would be found in many organizations. However, just like with commonly used reports and tables, filtering and selection techniques that limit the set of items to a size that is relevant yet observable can be applied to visual representations. Furthermore, querying tools can be added to a visualization itself to focus on the data of interest and also display item details that are not shown in the high-level visualizations presented here.

The next step in this work will be to investigate the usefulness of our proposed visualizations with ERP system users. Findings will be applied to fine-tuning the AM and DTM components. User studies will also provide the opportunity to determine the optimal placement of these components within existing enterprise system interfaces for making them easily and obviously accessible to users.

References

1. Babaian, T., Lucas, W., Xu, J., Topi, H.: Usability through system-user collaboration. In: Winter, R., Zhao, J.L., Aier, S. (eds.) DESRIST 2010. LNCS, vol. 6105, pp. 394–409. Springer, Heidelberg (2010)
2. Babaian, T., Lucas, W.: Composing interface demonstrations automatically from usage logs. In: Cordeiro, J., Maciaszek, L.A., Filipe, J. (eds.) ICEIS 2012. LNBIP, vol. 141, pp. 376–392. Springer, Heidelberg (2013)
3. Bobrik, R., Reichert, M., Bauer, T.: View-based process visualization. In: Alonso, G., Dadam, P., Rosemann, M. (eds.) BPM 2007. LNCS, vol. 7447, pp. 88–95. Springer, Heidelberg (2007)
4. Goldberg, J.H., Helfman, J.I.: Enterprise network monitoring using treemaps. In: Proceedings of the Human Factors and Ergonomics Society Annual Meeting, vol. 49, no. 5, pp. 671–675. SAGE Publications (2005)
5. Hipp, M., Mutschler, B., Reichert, M.: Navigating in complex business processes. In: Liddle, S.W., Schewe, K.-D., Tjoa, A.M., Zhou, X. (eds.) DEXA 2012. LNCS, vol. 7447, pp. 464–480. Springer, Heidelberg (2012)
6. Lambeck, C., Fohrholtz, C., Leyh, C., Šūpulniece, I., Müller, R.: Commonalities and contrasts: an investigation of ERP usability in a comparative user study. In: Proceedings of ECIS (2014)
7. Lambeck, C., Muller, R., Fohrholz, C., Leyh, C.: (Re-) evaluating user interface aspects in ERP systems—an empirical user study. In: Proceedings of the 47th Hawaii International Conference on System Sciences (HICSS), pp. 396–405. IEEE (2014)

8. Lucas, W., Xu, J., Babaian, T.: Visualizing ERP usage logs in real time. In: Proceedings of the 14th International Conference on Enterprise Information Systems (ICEIS 2013), pp. 83–90 (2013)
9. Parush, A., Hod, A., Shtub, A.: Impact of visualization type and contextual factors on performance with enterprise resource planning systems. *Comput. Ind. Eng.* **52**(1), 133–142 (2007)
10. Scholtz, B., Cilliers, C., Calitz, A.: Qualitative techniques for evaluating enterprise resource planning (ERP) user interfaces. In: Proceedings of the 2010 Annual Research Conference of the South African Institute of Computer Scientists and Information Technologists, pp. 284–293. ACM (2010)
11. Singh, A.: Designing adaptive user interfaces for enterprise resource planning systems for small enterprises. Doctoral dissertation, Nelson Mandela Metropolitan University (2011)
12. Shneiderman, B.: Creativity support tools: accelerating discovery and innovation. *Commun. ACM* **50**(12), 20–32 (2007)
13. Topi, H., Lucas, W., Babaian, T.: Identifying usability issues with an ERP implementation. In: Proceedings of the International Conference on Enterprise Information Systems (ICEIS-2005), pp. 128–133 (2005)
14. van der Aalst, W.M.P.: *Process Mining: Discovery, Conformance, and Enhancement of Business Processes*. Springer, Heidelberg (2011)
15. van der Aalst, W., et al.: Process mining manifesto. In: Daniel, F., Barkaoui, K., Dustdar, S. (eds.) *BPM Workshops 2011, Part I. LNBIP*, vol. 99, pp. 169–194. Springer, Heidelberg (2012)