SAwD - Socially Aware Design: An Organizational Semiotics-Based CASE Tool to Support Early Design Activities

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Abstract. Developing technology to attend to social demands is an increasing challenge for the Information and Communication Technology (ICT) area. Ubiquitous Computing, Wearable Computing, Social Software, and the Internet of Things are examples of how ICT has permeated personal and collective life. Technology affects people, even the ones who do not use it. Therefore, designing technology now requires higher social awareness and responsibility, as well as ethical commitment from all stakeholders. Naturally, such a process demands for artifacts and methods grounded on different theories and practices, capable of facilitating the understanding of the social world and its complexity, in an effective way. In this paper, we introduce a Socially Aware Design (SAwD) system which is a CASE tool designed to support early design activities when a problem is understood and a solution is proposed. This tool aids to articulate ideas from Organizational Semiotics and Participatory Design. We present the theoretical and methodological grounds of our work about the design rationale for SAwD and how it disseminates both the practice of a socially aware design and an adoption of theories.

Keywords: Socially Aware Computing · Organizational Semiotics · Participatory Design · Collaborative design tool

1 Introduction

In Software Engineering, Sommerville [20] and Chung et al. [8] draw attention to "early requirements" or "organizational requirements", arguing that knowing the problem and envisaging solutions before creating a technical solution tend to avoid large future expenditures regarding human, time and financial resources. If the problem context is not well understood, a "bad" or neglected requirement can trigger additional

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problems. These additional problems may raise maintenance costs, restrict or affect the technology necessary to solve the problem, affect the project's scope and lead to changes in other requirements. Changes in other requirements, for instance, may impact later on stages of the project, sometimes causing a product rejection by some stakeholders or even rendering unfeasible the whole project.

Traditional software development models (e.g., cascade, iterative and incremental) tend to focus problem understanding on the identification of functional and non-functional requirements [20]. This vision focuses on the solution of technical aspects and prevents a more comprehensive understanding of the problem being addressed, preventing those involved from having a wider sense-making of the problem and the proposed solution. A broader design view should include the point of view from different stakeholders, and pay attention to informal (e.g., culture, values, behavior patterns, preferences, etc.) and formal (e.g., laws, regulations, rules and policies) aspects related to these parties. However, IT professionals are rarely trained to deal with social, ethical and normative issues, and the mainstream methods, techniques and devices used do not favor the consideration of these aspects [4].

There is a relevant amount of works and initiatives that either recognizes the need for a sociotechnical approach for Information and Communication Technology (ICT) design, or that favors the focus and attention to non-technical issues, especially in the Human-Computer Interaction (HCI) field. However, there is still a demand for a design process that meets the needs of a diverse audience to make design socially responsible. One initiative is Baranauskas' Semio-Participatory model, which we refer here as a Socially Aware Computing approach to design [1, 5]. In such approach, Baranauskas articulates and extends ideas inspired by Organizational Semiotics (OS) [11] and Participatory Design (PD) [12], proposing a framework that considers a dialogue with design materials and, mainly, among individuals in their different roles (e.g., designer, developer, end-user, sponsor, other stakeholders) in order to conduct participatory work towards interactive system design. In Baranauskas' view, technical aspects of a system design depend on and affect the formal and informal aspects of organizations and society. As opposed to a technically centered perspective, the Socially Aware Computing support stakeholders in forming a wider sense-making of the problem and the proposed solution.

Baranauskas' approach has been applied in design contexts of high diversity in terms of users (e.g., skills, knowledge, age, gender, special needs, literacy, intentions, values, beliefs) and for creating different design products. For example: inclusive social networks [1], applications; physical devices [13]; interactive digital television [7, 14]; systems for supporting problem solving and decision making in a manufacturing organization [3]; and accessible technologies [18]. It has also been used as a theoretical and methodological ground for other design approaches and frameworks, such as [17]. However, although practical results have demonstrated the contributions of her approach for a social responsible design in both academic and industrial settings, there is a demand for tools that support it and allow inexperienced designers to treat informal and formal aspects in their projects in a guided and practical manner. Such tools may support the dissemination of the approach, its usage by other professionals in different design contexts, as well as the dissemination of its background theories, such as Organizational Semiotics and its artifacts.

In this paper, we draw on the Socially Aware Computing approach as a theoretical and methodological background for the creation of an online system that supports the approach itself. The CASE tool, named Socially Aware Design (SAwD), is developed by experts in the approach and IT developers. Its current version offers a subset of artifacts used, created or adapted by Baranauskas' research group in its different projects, and was experimented in a case study by members of the InterHAD[1] research group, from the Computing Institute of the State University of Campinas, to understand and organize the 17th International Conference on Informatics and Semiotics in Organizations (ICISO'16). The results suggest there were benefits of using an online and collaborative CASE tool to support Baranauskas' approach for organizing the ICISO'16 conference. The current version of the CASE tool is available for free use on the Web.

The paper is organized as follows: Sect. 2 introduces the SAwD approach and its background. Section 3 describes the methods and practices applied to design the SAwD system. Section 4 presents the case study, and Sect. 5 discusses some findings from the CASE tool design and the case study. Finally, Sect. 6 presents our final considerations and directions for future work.

2 Background Theories

Hall [9] introduces the notions of informal, formal, and technical levels in which humans operate and understand the world. The Organizational Semiotics (OS) theory proposes a structure nicknamed "Semiotic Onion" [21] to explain how these levels coexist in the context of organizations and information systems, explaining that any technical artifact is embedded in a formal system that, in turn, is embedded in an informal one. The informal system represents organizational culture, customs, and values that are reflected as beliefs, habits, and individual behavior patterns of its members. The formal corresponds to aspects that are well established and accepted, becoming social conventions, norms, or laws. Finally, the technical, situated at the core of the onion, represents aspects that are so formalized that they can be technically approached and supported. The Socially Aware Computing [2] understands the design process as a movement that begins at society, crossing the informal and formal layers of signs to result in a technical system considering relevant aspects of the informal and formal layers of knowledge of the social group. Baranauskas [4] argues that when a technical system is designed, it will impact on formal and informal layers alike, including the society and target audience.

The Socially Aware Computing approach makes use of other artifacts and methods created and inspired by OS to bring to participatory discussions a structured and systemic view of the problem. This view involves knowledge layers (informal, formal and technical) and their interdependence, brought to discussion in order to propose a solution for a complex social system in which people and their behavior patterns are organized. For instance, the Problem Articulation Methods (PAM) from OS [10]

[1] http://www.nied.unicamp.br/interhad.

provide practical artifacts (e.g., structures, guides, templates) that support the problem understanding from different perspectives. In Baranauskas' approach, the method attempts to bring out the complexity of the addressed problem and the solutions proposed among and for different stakeholders in a participatory way. Because problem clarification should be the first step in a project, the PAM can be used regardless of the design process, the technologies that will be used, and even the nature of the design.

The Stakeholders Identification Diagram (SID) and the Semiotic Framework (SF) are examples of PAM's artifacts. The SID [11] facilitates the identification of the ones direct or indirectly involved in a particular design process, allowing the identification of stakeholders according to five different categories (Operation, Contribution, Source, Market and Community) that represent different levels of involvement, interests, and expectations. The SF [21], in turn, favors the identification and organization of requirements according to six different levels that represent different aspects of signs. The first three levels can be related to technological issues (the physical, empirical, and syntactic), and the other three levels can be related to aspects of human information functions (semantic, pragmatic and social world).

Baranauskas and colleagues have also proposed and adapted other artifacts to support problem clarification and prospection of design solutions. For instance, the Evaluation Frame (EF) [1] is an artifact to favor anticipation and discussion of problems and solutions related to each stakeholder identified through the SID, contributing to the identification of requirements and issues that might impact the solution to be designed. Other examples are the Culturally Aware Requirements Framework, Value Identification Frame [15] and Value Pie [16]. The SAwD CASE tool is intended to support the use of such artifacts in a collaborative and practical way.

3 SAwD: A CASE Tool to Support the Socially Aware Computing

The SAwD[2] CASE tool is a result of a design process inspired by Baranauskas' Socially Aware Computing [1]. The activities were structured in three main steps: (i) understanding the problem domain to identify general requirements; (ii) proposing and developing the CASE tool; and (iii) technical evaluations and improvements.

Problem Understanding: Activities begun early 2010 with only three people (researchers), one of them an **expert** in Organizational Semiotics and Socially Aware Computing. Weekly meetings were held to discuss and brainstorm about the possibility of a set of tools to support the use of PAM artifacts. It was then decided to use PAM artifacts to understand PAM artifacts themselves, and how they could be useful as an online CASE tool that supports the process of problem understanding. The Stakeholder Identification Diagram, Evaluation Frame and Semiotic Framework were the 3 artifacts used to support this activity; they were available in a plug-in for the Sakai environment used in closed distance learning courses. The project was initially named WebPAM.

[2] www.nied.unicamp.br/dsc.

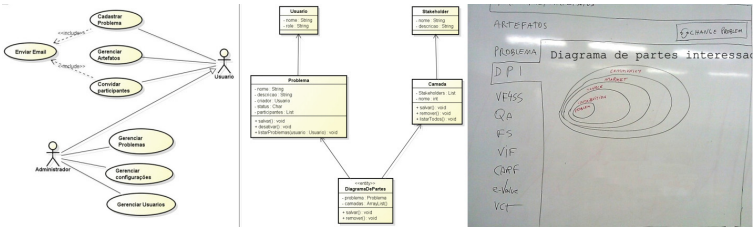

Fig. 1. UML diagrams and design proposals for the CASE tool.

Solution Proposal and Development: Iteratively, the team evolved the problem understanding, specifying and prototyping a solution to support the collaborative and open use of PAM artifacts on the Web as part of design projects. The Brain Drawing participatory technique was used to generate proposals for the tool user interface. After several iterations, a first formal specification of the CASE tool was developed, and four new members (undergraduate students) were added to the project to work in software engineering and development activities. Figure 1 illustrates the UML use case and class diagrams, as well as one prototype developed in 2012 to achieve a usable digital version of the artifacts.

Evaluation: The tool's first version, see Fig. 2, was evaluated by 24 Information Technology undergraduate students of the University Center of Maringá[3] in Brazil (UNICESUMAR). The evaluation was conducted using the System Usability Scale (SUS) [6]. The students discussed a hypothetical problem by means of the CASE tool, and then evaluated it by answering a SUS questionnaire.

Fig. 2. The CASE tool's first version named WebPAM.

Considering that the SUS questionnaire scale ranges from 0 (worst possible score) to 4 (best possible score) mapped for Usability Goals [19], the 2012 version of the CASE tool had a score between 2 and 3 for Effective (effective to use), Efficient (efficient to use), Utility (have good utility) and Learnable (easy to learn). Memorable (easy to remember how to use), in turn, had a score lower than 2. Even though the

[3] http://www.unicesumar.edu.br.

overall results are positive, the results indicated that the CASE tool could be improved in several aspects, including usability and accessibility ones.

Based on the results from the first evaluation and on the artifacts used to clarify the problem, the team started improvement tasks focusing both usability and technical improvements. From a back-end perspective, the nature of the data processed (mostly unstructured data, such as texts and images) led to the adoption of the non-relational (noSQL) database MongoDB[4]. Also from a back-end perspective, the need for efficiency when dealing with a relatively large number of concurrent connections led to the adoption of the Node.js[5] runtime, due to its event-driven, non-blocking I/O model. To improve the usability, it was decided to adopt the well-established and documented Material Design language from Google[6]. Therefore, from a front-end perspective, it was decided to adopt Angular Material[7], which is a reference implementation of Google's Material Design Specification for the Angular.js[8] framework, and that provides reusable, well tested and accessible UI components. Finally, to improve the data communication between back-end and front-end, it was decided to adopt the Socket.io[9] library, which allows real-time bidirectional event-based communication, making possible for users to collaborate remotely in real time during the use of OS artifacts. Figure 3 shows an abstraction for the SAwD Software Architecture: the front-end (chat, people, description, artifacts) are linked to the back-end (messages, artifacts data sharing) and communication between back-end and database.

The results from the problem clarification and the tool evaluation led to a change in the project's purpose. From a web tool that would support the open use of PAM's artifacts it was transformed in a tool for supporting problem understanding from a systemic and socially responsible perspective, i.e., Baranauskas' view for design, in an open and collaborative way, regardless the nature of the problem and solution to be designed. The CASE tool was, then, renamed to Socially Aware Design (SAwD). During the following years, technologies were experienced and the first version of the

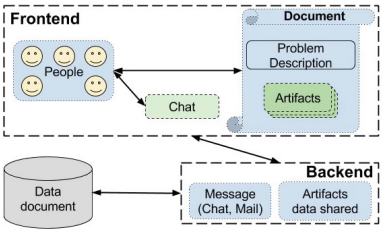

Fig. 3. System components for SAwD tools.

[4] https://www.mongodb.org/.
[5] https://nodejs.org/.
[6] https://www.google.com/design/spec/material-design/.
[7] https://material.angularjs.org/.
[8] https://angularjs.org/.
[9] http://socket.io/.

SAwD CASE tool was developed. In August 2015, the CASE tool first version was made available online and is being experienced by the InterHAD research group since then.

4 Tool Experimentation

The International Conference on Informatics and Semiotics in Organisations (ICISO), promoted by the International Federation for Information Processing (IFIP), is held annually to discuss new research outcomes, applications, challenges and trends in OS. The first edition was held in 1995 in Twente, The Netherlands, and since then it has taken place in different countries (e.g., Brazil, Canada, China, France, United Kingdom). Over the years, the conferences covered research themes such as people and information systems; web of things; information and knowledge management in complex systems, and socially aware organisations and technologies: impact and challenges. In 2016, ICISO will be held for second time in Campinas, Brazil.

This activity involved a group of 10 people with experience in using OS artifacts and in organizing conferences. Because the participants were experienced in both OS and the problem domain, this was considered an ideal scenario to evaluate the current version of the CASE tool in terms of possible conceptual problems, technical issues and overall usability. This scenario also highlights how the CASE tool can be used for a wide range of problem understanding contexts, not only the development of a technological product. Figure 4 illustrates the beginning of the planning activities, in which the group uses the SID to list and map every stakeholder that is involved and may somehow affect/be affected by the conference. Participants identified and mapped stakeholders from different layers, for instance, while technical stakeholders (e.g., EasyChair) are placed in the onion's core, social ones (e.g., Audience) are placed in the outermost layer of the onion.

Following, the participants used the EF to discuss how the conference might influence/affect or be influenced/affected by the different stakeholders identified

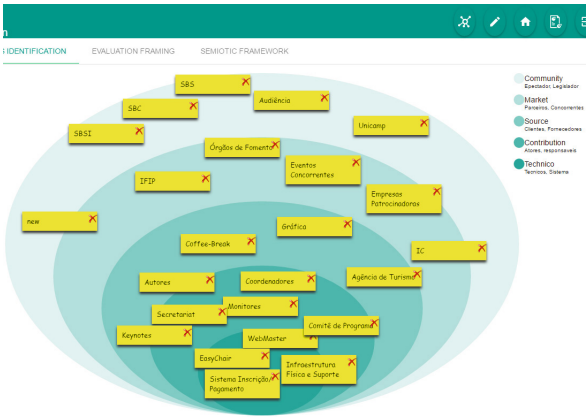

Fig. 4. SID for ICISO'16

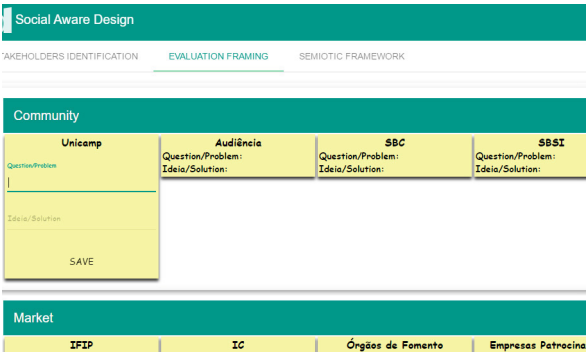

Fig. 5. Evaluation frame for ICISO'16

through the SID. Figure 5 illustrates the design choice for the digital version of the EF artifact developed for the CASE tool. Every stakeholder identified in the SID is automatically displayed in the EF to assure they will not be forgot when switching between the artifacts. In the EF, the participants discussed every stakeholder identified previously in the SID, raising possible problems regarding them, and then discussing ideas and solutions for these problems.

5 Discussion

The SAwD CASE tool goes beyond a set of digital version of OS-based artifacts, being a solution for bringing social awareness to development processes. The CASE tool favors joint problem understanding and provides a practical way for a group of people to perceive and discuss how problems and design solutions may affect society. The following points reinforce how the CASE tool supports social awareness in design:

1. It is a project-oriented tool that allows the collaborative, free and open participation;
2. It is based on the PAM, providing a solid base for problem understanding;
3. Allows the inclusion of new artifacts, which, if needed, can share or access data with or from other used artifacts;
4. It has an internal communication tool (chat) with messages persistence, allowing both synchronous and asynchronous communication between project members;
5. Real time data synchronization allows project members to work collaboratively in real time in the same or different artifacts;
6. It allows the creation of a consolidated report of the project, providing a holistic view of the project in a single document.

The online CASE tool enables new possibilities to reach stakeholders and involve them in the process of problem understanding and solution proposal. Because the tool allows people to remotely join the discussion and collaborate, physical distance is no longer an issue when it comes to stakeholders being included in the process. In this sense, a broader stakeholder engagement contributes to a more comprehensive and socially aware design process.

In the CASE tool current version, the included artifacts allow the discussion of relevant questions related to culture and human values during problem understanding. These artifacts were evaluated through practical research projects and learning activities, and the real case study about the ICISO'16 organization, providing positive results regarding a socially aware design. Additionally, the use of the CASE tool can also increase awareness about the importance of the socially aware design approach, especially among designers, developers and researchers without experience with OS. Because some of the artifacts were used to clarify the design problem for the SAwD, it was also possible to see technical issues (e.g., the used database system and interface framework) and abstract requirements (e.g., collaboration, flexibility) that were identified since the early stages of design, and that could have been neglected/forgotten if stakeholders, their problems, ideas and needs have not been considered in an explicit way.

Finally, the use of the CASE tool allowed an understanding about how this new set of tools would affect its stakeholders and society, with focus on how each stakeholder can benefit from this tool.

6 Conclusion

Technology influences people's daily activities, which, in turn, are formally defined. Thus, the design of a solution goes through informal, formal and technical layers of signs. By using artifacts from OS it is possible to understand and discuss the social impacts of a proposed solution; therefore, the development team may be able to make informed decisions regarding stakeholders' culture and values. There was a need for tools to support this process of problem understanding and ideally, these tools should be available to every stakeholder, so that they could contribute to the understanding of the problem and be part of the development of a solution that affects positively everyone involved.

The SAwD implements some PAM artifacts and allows a collective work for discussion and understanding of the problem, leading the group to build a solution that makes sense to all the involved ones. The Tool is available online, favoring participatory work, enabling designers to propose creative solutions and promoting a decision-making space with stakeholders. The tool is in its first increment with six artifacts, and some minor programming and usability problems have been reported during the case study. These problems are addressed and the tool is being gradually improved. For future work, new artifacts will be incorporated into the tool to support the SAwD approach, such as Pereira's [16] Value Pie. These artifacts are relevant in the process of socially aware design and will be part of the SAwD CASE tool in a new deliverable.

Finally, the tool is experienced in Computer Science graduate and undergraduate disciplines, such as Software Engineering and HCI (Human Computer Interaction), at University of Campinas, Federal University of Technology – Paraná (UTFR) and Federal University of Paraná UFPR in 2016 first semester. Its usage will contribute to both the evaluation of the tool itself, and the dissemination of the OS artifacts and the Socially Aware Computing approach to design.

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