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A Design Framework for Mobile Collaboration

Pedro Antunes
Faculty of Sciences of the University of Lisboa,
Campo Grande, 1700 Lisboa, Portugal
Tel: +351-21-7500605
Fax: +351-21-7500084
Email: paa@di.fc.ul.pt
Web page: http://www.di.fc.ul.pt/~paa/

INTRODUCTION

Mobile collaboration involves people working together and moving in space. Research in mobile collaboration has primarily focused on technical issues like connectivity support or remote information access. We argue there is a lack of research on many non-technical issues vital to design mobile collaboration systems, disentangling the relationships between collaboration, work context and mobility.

Our fundamental concern is to go beyond the technical issues towards the assimilation of the mobility dimension in all processes shaping collaborative work, including information sharing, context awareness, decision making, conflict management, learning, etc. This chapter aims to codify into a design framework:

- Some fundamental human factors involved in mobile collaboration;
- Several guidelines for developing mobile collaboration systems.

The design framework provides general constructs identifying phenomena of interest necessary to inquire about the work context, human activities and system functionality. The framework identifies *what* information may interest designers, bounding their relationships with the other stakeholders. The framework also guides the design process, identifying *how* user requirements may be applied during the implementation phase.

The framework has been validated in several real-world design cases. Two cases will be briefly described. This research contributes to the design of mobile collaborative systems. The most significant contributions are related to artifacts and emphasize that designers shall explore the potential of artifacts to support concerted work and sensemaking activities.

BACKGROUND

Several conceptual frameworks have been proposed in the Group Support Systems (GSS) field (DeSanctis & Gallupe, 1987; Nunamaker et al., 1991; Pinsonneault & Caya, 2005). However, these frameworks capture the notion of place in a very restrictive way, more tied to group proximity than mobility, where geographical references play a central role in tying information together (Mackay, 1999).

The above limitation is being tackled in two closely related research areas: Collaborative Spatial Decision-making (CSDM) and Spatial Decision Support Systems (SDSS) (Nyerges et al., 1997). SDSS address the combination of DSS with Geographical Information Systems (GIS), while CSDM studies the integrated support to collaboration, decision, mobility and geographical information.

We find several studies on the infrastructural basis of SDSS. (Zhao et al., 2002) identify the infrastructural requirements for SDSS. Gardels (1997) and Touriño et al. (2001) contribute with the integration of multimedia with geo-referenced data. Hope et al. (2000) tackle the access to remote databases by field workers, while Pundt (2002) addresses data visualization in the same context. All of these research projects do not directly address mobile collaboration but explore basic features necessary to support this functionality.

Regarding the human factors of SDSS, we account for studies of user interaction with multimodal and tangible GIS interfaces (Coors et al., 1999; Rauschert et al., 2002). In the same line, we also cite developments in synthetic collaborative environments for geo-visualization (Grønbæk et al., 2002; Manoharan et al., 2002). However, these research studies address fixed work settings.

More inline with collaboration studies, we find several research emphasizing the need to support group modeling in CSDM (Armstrong, 1994, 1997). Some propose very specific solutions, such as the integration of workflow management with SDSS (Coleman & Li, 1999).

Finally, addressing the broad-spectrum CSDM design, we find the work from Tamminen et al. (2004), who propose an integrated framework with guidelines for eliciting innovative ideas for mobile technology based on context-awareness (although not collaboration). Nyerges et al. (1997) also propose an integrated framework for CSDM, but the framework is specific for the transportation context.

As demonstrated by the research previously cited, there is a whole new perspective over GSS brought by the mobility dimension, making CSDM quite distinct from GSS. However, the most important distinctions are not captured by current GSS and CSDM frameworks: (1) the central role of geo-references in the information architecture; (2) the interaction support to obtain, manage and share geo-referenced data while in the field; (3) the role of geo-references in modeling group work; and (4) the added impact of context awareness in the system design, regarding in particular work place mobility. Our perspective is that we need to integrate these various phenomena into a meaningful and purposeful framework.

THE FRAMEWORK

The framework is bounded by two major requirements: it has to be open for exploring and interpreting mobile collaboration in various settings, thus requiring relatively abstract elements and constructs; and it has to link them in a purposeful way. Our major goal is to set the initial boundaries for inquiring about mobile collaboration, setting at the same time a design roadmap.

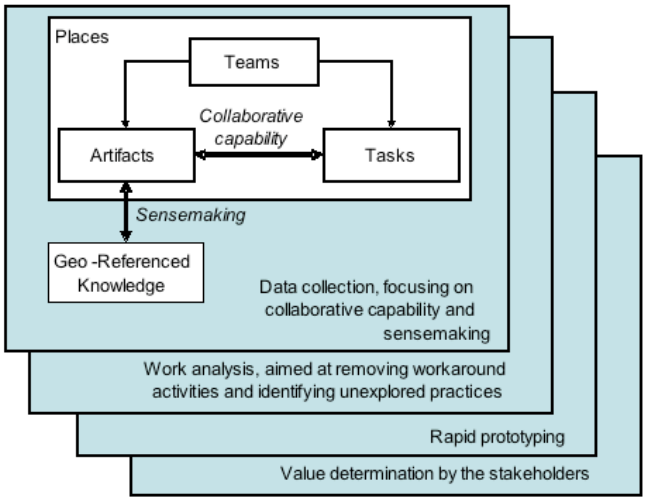

Figure 1 – Design framework for mobile collaboration

The framework, shown in Figure 1, is structured around five basic elements and four design phases. The basic elements are teams, tasks, artifacts and places, while the design phases consider data collection, work analysis, prototyping and value determination. As described below in more detail, the basic elements have an important role throughout the design phases, structuring the various design activities taking place in each phase.

The relationships between the five basic elements are defined as follows. Teams manipulate artifacts to accomplish tasks in certain places. This combination of elements affords the most common spatial arrangements that we find in collaborative settings. The same argument applies to artifacts and tasks, were we may consider having artifacts/tasks fixed in a single place, distributed or moving through several places. We assume these elements are consensual in the CSDM field, so that no further considerations are necessary.

In contrast, the relationship between artifacts and tasks, noted as *collaborative capability*, deserves further consideration. The notion of collaborative capability (Nunamaker et al., 2002) identifies several categories of increasing ability for successful creation of meaning, ranging from the individual, collective and coordinated to the concerted creation of meaning. The theory is that organizations will increase their potential to create value by increasing their collaborative capability. Further details and validity tests of this theory can be found in (Bach et al., 2004; Qureshi & Briggs, 2003). We realize this theory has an immediate impact in CSDM design, because work processes are affected by geographical constraints, and thus there may be an opportunity for increasing the organizational effectiveness. From this theory we draw an implication for design: the development of shared artifacts, supporting concerted tasks, should be preferred to the development of individualized artifacts, so that work processes become independent of geographical constraints.

The final framework basic element is geo-referenced knowledge. We regard the manipulation of artifacts, in mobile collaboration, not an end in itself but a mean to construct and augment shared knowledge about the work space and the objects found on it. This shared knowledge is necessarily tied to geographical references and mediated through artifacts. We may characterize the relationship between artifacts and geo-referenced knowledge as *sensemaking*: an ongoing process aiming to create order and make retrospective sense of what occurs (Weick, 1993). We argue sensemaking precisely captures the fundamental nature of mobile collaboration: people handling together information in fluid contexts. As the sensemaking theory posits, the outcomes from mobile collaboration result from “thinking by doing” (Weick, 1993), since

problems and solutions are highly context dependent. The presence of this element in the framework introduces one more implication for design: artifacts must enrich sensemaking by integrating mechanisms for searching, browsing, visualizing or summarizing geo-referenced information.

We now turn our attention to the design phases. The first phase concerns data collection aimed at understanding the work context. In this phase we adopt the contextual inquiry method (Beyer & Holtzblatt, 1998), which utilizes a mix of ethnography and interviews to understand the work. While contextual inquiry is context independent, this phase is structured around the framework basic elements, and specifically collects data about collaborative capability and sensemaking (how users organize themselves and make sense of geo-referenced data).

The second phase is dedicated to analyze work from the field data. Again, the framework plays an important role centering the analysis around places, artifacts and geo-referenced knowledge, focusing the modeling activity on the phenomena of most interest to mobile collaboration. We also suggest that attention to collaborative capability and sensemaking will raise new opportunities for removing workaround activities and identifying unexplored work practices, which are characteristic of innovative design solutions (Vicente, 1999).

The third phase is rapid prototyping. Here, low- or mid- fidelity prototypes serve to communicate with the stakeholders and evaluate the feasibility of the design ideas. The prototypes are fundamentally built around artifacts, task support and geo-referenced knowledge management.

Finally, the last step concerns the value determination by the stakeholders. We have been using context interviews (Beyer & Holtzblatt, 1998) to gather feedback from the stakeholders about the design solutions. Next, we describe two cases where this framework has been applied.

CASE STUDY ONE

This case addressed work redesign at a national agency responsible for inventorying geological resources. One major problem with this organization was that an inventory process took a long time to complete, mostly because experts had to go repeatedly to the field to retrieve information and resolve conflicts.

The framework helped organizing the field observations and interviews with experts involved in the process. This way we came to understand how work moved between the office and the field, what artifacts were used, and how geological information was gathered, analyzed, organized and consolidated. The inventory process required a combination of individual and collaborative activities, since expertise from different fields had to be combined.

Then, we began to analyze the work process, focusing on the five basic framework elements: teams, tasks, artifacts, places and geo-referenced knowledge. At this stage we realized that a typical geological inventory took about two years to complete, as a consequence of several visits to the field, multiple activities in the office and many gap periods. Several critical incidents concurred to this situation: (1) bad initial data; (2) the occurrence of doubts when in the field or in the office; (3) the occurrence of conflicts between experts, which could only be resolved by sending someone to the field for confirmation; and (5) the concurrent execution of multiple inventory processes, causing management and planning difficulties. The framework had also a crucial role in the identification of the major design requirements:

- Fieldwork evolved around two artifacts: the field book and the combination of a map with a transparent overlay. The map/overlay allowed drawing inventory data, while the field book was used to annotate supplementary information, including doubts and

concerns arising in fieldwork. All relevant knowledge was geo-referenced, both in the map/overlay and field book.

- The field book was personal, signifying a reduced collaborative capability. This indicated that sharing the field book could increase the collaborative capability.
- Sensemaking was problematic, because of the many unresolved doubts arising during fieldwork and difficulties reconstructing the field context in the office. Also, geo-referenced knowledge was distributed between the field book and map/overlay, which were difficult to co-relate. These observations indicated there was ample opportunity to develop information management mechanisms aiming to increase sensemaking.
- The inventory process was delayed by the need to swap work between the office and the field, a situation which could be resolved by increasing the team's collaborative capability: bringing all relevant stakeholders together to resolve problems as they were appearing in the field or in the office.

These requirements lead us to prototype a digital artifact integrating the field book and map/overlay, and supporting cross-referencing and searching. We also allowed the fieldworker to contact the office workers using GPRS and an instant messaging mechanism. The redesigned work process allowed the fieldworker to get in contact with the office workers and immediately exchange comments on any occurring problem. The elements in the field book were synchronized to keep the conversation in context and facilitate sensemaking. Also, the fieldworker had an easier task when moving back to the office. Because doubts were resolved in the field, there was less time spent in the office. Addressing our observation that all knowledge were geo-referenced, the instant messages exchanged between the field and office workers were preserved in the field book with automatic associations to the geographical position of the fieldworker, thus keeping the doubts, comments or opinions in their context.

The prototype was evaluated with a field test and contextual interviews with several experts from the national agency. The obtained results indicate that the system increased sensemaking and collaborative capability. Related to sensemaking, the participants regarded very positively the expeditious way to locate points and associate them in the field book. Related with collaborative capability, the participants were extremely favorable to the communication between field and office workers, effectively resolving problems occurring in the field and thus simplifying the whole inventory process. More details about this case study can be found in (Antunes & André, 2006).

CASE STUDY TWO

This case involved work optimization in a small accountancy company, where meetings were the primary coordination mechanism. The company was not satisfied with the meetings productivity and regarded technology as a silver bullet. Different alternatives were experimented, which included the use of GSS and workflow tools, but cultural factors contributed to an unenthusiastic view of these technologies, since they imposed too much structure to meetings. We proposed an alternative approach, which would not conflict with their informal work organization. The proposal considered the use of Personal Digital Assistants (PDA) in meetings.

The framework allowed organizing the several data collected from interviews and meeting observations. We observed that the company had three types of meetings: (1) briefings, aimed to discuss ongoing projects; (2) planning meetings, where tasks and personnel were allocated to new projects; and (3) process definition meetings, where the whole collection of projects was

taken in perspective to ensure an adequate allocation of resources. Different teams participated in these meetings, accomplishing different tasks and using different artifacts and knowledge.

One issue raised by the framework during data collection was to identify people and information mobility related with meetings. During work analysis we characterized the specific nature of the artifacts moved by the accountants, such as meeting agendas, "to do" lists and calendaring information. We came to understand two fundamental problems related with collaborative capability and sensemaking:

- It was difficult to move artifacts out of meetings. Sensemaking was affected by the lack of context, e.g. when a meeting outcome was delivered to someone that did not participate in the meeting;
- Meetings were affected by reduced collaborative capability, in particular the absence of a shared whiteboard capable to integrate the data brought by the participants.

These problems lead to the development of a prototype with the following characteristics: use PDA to bring information into and out of meetings; integrate the meeting information in a shared whiteboard; and supply a sensemaking mechanism capable to display the information flows across several meetings in an integrated way.

This case study was evaluated in two dimensions: framework and prototype. Selected accountants participated in evaluation tasks carried out at each design stage, evaluating the quality of data collected, work analysis, design ideas and prototype. The obtained feedback indicated that the framework was useful to elicit the organizational context of the problem. The evaluators also considered the data collection phase very useful and efficient. The work analysis phase was also considered very useful to help them understand the possibilities and limitations of the proposed solution.

Concerning the prototype, the evaluators considered the sensemaking functionality very useful and adjusted to their needs; and thought that the simplicity of the PDA role bringing information in and out of meetings was adequate to their expectations, provided that not much text editing was required. More details about this case study can be found in (Antunes & Costa, 2002; Costa et al., 2002).

CONCLUSION

One important advantage of design frameworks is codifying current knowledge and best practices into design guidelines directly pointing towards where innovation may emerge. Our framework leads designers to identify meaningful ways to articulate places, users, tasks, artifacts and geo-referenced knowledge. The framework also guides the design process, keeping the designer focused on the issues most relevant to mobile collaboration.

The presented case studies highlight two different contexts where the framework pointed directly towards these concerns and definitely was useful informing the adopted designs. The evaluations conducted within the case studies confirmed the relevance of the framework as well as the relevance of the adopted design solutions. Artifacts emerged as the most important area of concern in mobile collaboration, mostly because they have potential to increase the collaborative capability and sensemaking.

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TERMS AND DEFINITIONS

Mobile collaboration: People collaborating and moving through space.

Design framework: A collection of general constructs identifying phenomena of interest and guiding the design process.

Collaborative Spatial Decision-Making: The integrated study of collaboration, decision-making and mobility support.

Collaborative capability: Defines four levels in increasing ability to create meaning: individual, collective, coordinated and concerted.

Sensemaking: An ongoing process aiming to create order and make sense of what occurs.

Geo-referenced knowledge: Knowledge that is tied to a geographical reference.

Group Support System: A technological system supporting and mediating group work.