Handling Human Factors in Cloud-based Collaborative Enterprise Information Systems

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Keywords: Human Factors, Enterprise Information Systems, Collaborative Networks, CSCW, Social Computing.

Abstract: Many business sectors are currently facing emerging globalized scenarios that require effective coordination of heterogeneous teams, involved in complex collaborative processes. For most of those processes, organizations do not count with software tools providing an adequate support for collaboration needs from a human-centred perspective. In this context, the recently born field of Collaborative Networks has introduced some lines of work that must be deeply explored in order to improve collaborative processes support in Enterprise Information Systems. Taking this paradigm as reference, in this article we provide a review of the main areas related to collaborative work, enumerate some of the most common collaborative software tools that are being adopted in organizations worldwide, and finally present a framework for the modeling and development of Cloud Computing based Organizational Collaborative Systems as a solid basis for the handling of human factors in global organizations.

1 INTRODUCTION

After the consolidation of the Age of Information, the next major changes that are expected to happen in many business areas (such as software, finance or health industries), are related to the implementation of industrial models for those processes that are highly influenced by human factors. According to some recent studies, the transformation that those business areas will experience in the near future will be driven by well-known human-related needs: the adequate management of the knowledge that each organization has at its disposal, the standardization of those activities that are constrained by purely human resources (such as creativity or expertise in the case of innovation) (Amabile 1996), and the proper handling of dispersed heterogeneous teams (Brown, 2011). In the case of Enterprise Information Systems (EISs), one of the first steps that must be taken for undertaking these challenges is to ensure an adequate support for the collaborative processes in which people and technologies are involved altogether. Recent paradigms such as Cloud Computing encourage this evolving by easing the construction of homogeneous computer-mediated scenarios.

On the other hand, new research lines appear from areas such as the novel field of Collaborative Networks (CNs) which is focused on the structure, behaviour, and evolving of dynamics of networks of autonomous entities that collaborate to better achieve common or compatible goals (Camarinha, 2005). As we have already suggested (Antonaya, 2013) the adaptation of EISs to modern collaboration needs is enclosed to the integration of three distinct domains: Organizational Structures, Collaborative Workflows, and Groupware Tools. Nevertheless, the multidisciplinary nature of collaborative work implies that any research must consider not only organizational and technological, but human factors too.

In this article we examine some of the human factors that must be considered during the adaptation of EISs to nowadays global collaboration needs. The article is structured as follows: section 2 provides a review of key areas related to collaborative work and CNs; section 3 revises most common software collaborative tools that are being adopted by organizations worldwide. Finally, section 4 presents a framework for the modeling and the development of Cloud Computing based Organizational Collaborative Systems (Antonaya, 2012).
2 HUMAN FACTORS ON COLLABORATION

The history of the development of computer interactive systems demonstrates that human factors are what ultimately determine the success or failure of the new methods and tools that are intended to be implanted (Shum, 1997). In addition, current needs for collaboration imply that human factors must be considered from the point of view of both individuals and groups. In order to identify key human factors and the main difficulties that arise when facing them in computer-mediated working scenarios, we have considered three main areas of study: Computer-Supported Cooperative Work, Human-Computer Interaction, and Psychology of Organizations. These areas are reviewed in following sections 2.1, 2.2 and 2.3, and some of the main human factor that have been identified are exposed in section 2.4.

2.1 Computer-Supported Cooperative Work

The area of Computer-Supported Cooperative Work (CSCW) is a multidisciplinary field of study whose main objective is to find out how computers can help groups of people to work in a coordinated manner (Grudin, 1994).

There are many results regarding the area of CSCW that must be considered when studying human behaviour in computer-supported working scenarios. One of the most valuable results is the concept of Awareness, which can be defined as the conscious perception or knowledge about an object or event (Dourish, 1992). As a matter of fact, the study of human factors in CSCW implies that special attention is required to be paid to the following types of awareness: Informal: online members of a community, the activities for which they are prepared, and their availability; Structural: formal organization of a group and the working relationships that exist between its members; Social: social connections that exist between the members of a group; Conversational: communication activities that are being carried out; Task: actions that must be performed to accomplish a task; Change: changes performed on shared items by other members of a group; Workspace: interactions performed on a shared workspace by other members of a group; Concept: manner in which a particular knowledge fits to the knowledge that people already keep (Schmidt, 2002).

From the previous list of types of awareness, it can be deduced that an effective support for human factors in CNs requires dealing with very heterogeneous issues: user typologies, characteristics and behaviours, goals to be achieved, tasks required to be performed, and situations or contexts in which each activity occurs.

2.2 Human-Computer Interaction

The area of Human-Computer Interaction (HCI) is focused on the creation of User Interfaces that effectively satisfy the needs of users.

Many of the challenges that have been faced within this area have been historically focused on single-user systems (Bannon, 1991). Nevertheless, new lines of research are addressing the need for incorporating social aspects in system designs. Most of those researches could be framed within the emerging concept of Social Computing, which is defined as the computational facilitation of social dynamics, as well as the design and use of information and communication technologies that consider social context (Wang, 2007). In fact, social factors have already been discussed for many particular scenarios, as in the case of Office Automation, although the unit of analysis has been progressively translated from single offices or workplaces to full organizations or societies (Ala Mutka, 2009).

Anyway, human behaviour in collaborative working scenarios must be faced as an individual and social question, so lessons learned from success histories as the case of social networks must be considered when designing social interfaces for CNs and collaborative EISs too.

2.3 Psychology of Organizations

The area of Psychology of Work and Organizations is focused on the study of human behaviour in working and organizational contexts, both to individual and group levels.

Most of the results achieved in this field have not been obtained from computer-mediated scenarios, and are attached to reduced geographical locations such as offices or factories. All the same, those results should be translated to computer-mediated scenarios, especially when considering emerging organizational models like adhocracies, virtual enterprises and networked organizations (Griese, 1998). In these new contexts, elements such as organizational structures or business processes tend to be diffused and confusing for people.
Given the premises above, it seems necessary to assume some proposals formulated from psychology in order to improve the support for collaboration that is provided through Social Computing, as well as certain work-related constructs such as motivation, resilience, self-efficacy or work-engagement.

2.4 Identified Human Factors

In order to illustrate some of the key human factors that have been identified, in Table 1 we expose some that has been obtained through the revision of the scientific literature that has been generated from the three selected areas (Parameswaran, 2007), (Dieng, 1999), (Grudin, 1985), (Hoc, 2001).

<table>
<thead>
<tr>
<th>Factors</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disparity between work and benefit</td>
<td>Everyone in a working team must benefit from the use of technologies, since a critical mass of users is essential for the success of any collaborative system.</td>
</tr>
<tr>
<td>Motivation for Participation</td>
<td>Anonymity seems to be the general rule for participation in online communities, so an absence of incentives can have a critical impact on the level of non-anonymous participation.</td>
</tr>
<tr>
<td>Cooperation and Altruism</td>
<td>Cooperation processes often require altruistic behaviours by part of participants, although the real motivation for altruistic behaviours has not been clearly identified yet.</td>
</tr>
<tr>
<td>Organizational Culture</td>
<td>Symbols, language and practices constitute part of what is known as Organizational Culture, and that must be provided through computational mechanism when tangible workplaces do not exist.</td>
</tr>
<tr>
<td>Organizational Identification</td>
<td>People tend to identify with the company or team they belong to. In geographically dispersed teams, the lack of traditional human relationships must be replaced by tools such as social networks.</td>
</tr>
<tr>
<td>Occupational Stress</td>
<td>Poor or hindered communication, diffuse definition of organizational roles and lack of feedback on one-self performance can produce a negative impact on Occupational Stress.</td>
</tr>
<tr>
<td>Role Ambiguity</td>
<td>Role Ambiguity is the uncertainty about what actions must be taken in order to fulfil the assigned role.</td>
</tr>
</tbody>
</table>

There is a wide range of software tools that can result highly useful in order to apply solutions for factor listed in Table 1. In fact, some of them are under study now through the analysis of several Internet applications like wikis, social networks or MMORPG games.

In resume, the multidisciplinary nature of collaborative work requires a deeper study of how collaborative software tools can support human factors that influence on collaborative processes that are performed in computer-mediated environments.

3 COLLABORATIVE TOOLS

In this section we provide a general review of the most common types of tools that are currently being used by organizations worldwide in order to increase their internal levels of collaborative activity. Nevertheless, these tools present some lacks relating collaboration that must be also remarked (Orlikowski, 2001). In this sense, the review is focused in three domains taking into consideration the three main components of collaborative processes, known as the 3Cs of Collaboration: Communication, Coordination and Cooperation (Ellis, 1991). So, Communication Issues are reviewed in section 3.1, Coordination Issues are reviewed in section 3.2, and finally Cooperation Issues are reviewed in section 3.3.

3.1 Communication Issues

Nowadays organizations can select among a large amount of tools intended to facilitate communication between its members. However, it is remarkable that communication technologies must facilitate smooth and natural communication activities, avoiding the coexistence of an inadequate number of different communication channels. An excess number of communication mechanisms can lead to a harmful consumption of people attentional resources, since users are required to manage every different channel independently. Although it is nearly impossible to replace certain communication tools, such as telephone, some synchronous communication technologies can lead to an increasing amount of interruptions while work is being performed. These interruptions can consequently produce a negative impact on the performance exhibited when teams are involved in complex processes, and lead to an increase in the factor of Occupational Stress that was listed in Table 1 (Speier, 1999).
3.2 Coordination Issues

Coordination tools are usually oriented to the management of individuals and teams that are working in a cooperative way in order to fulfil organizational goals (Dietrich, 2013). These tools are very popular since they allow flexible management, and fits typical hierarchical structures of traditional organizations. However, additional efforts are usually required, especially when team members are geographically dispersed (Nouri, 2013). On the other hand, many of these tools do not allow certain activities and constraints to be specified with enough detail, and required resources for the accomplishment of organizational goals cannot be attached to those specifications.

A further problem arises when considering the negative impact on the Role Ambiguity factor that was listed in Table 1, and that can appear if required tasks are not properly specified, or people consider that assigned tasks do not match their skills or responsibilities.

Additionally, most of these tools do not provide adequate support to the types of awareness explained in section 2.1. This can be considered a significant lack in order to achieve the full acceptance of a system by part of end users.

3.3 Cooperation Issues

Nowadays, cooperation and collaboration tools are being applied in many different domains. The evolution of communication technologies and the rise of technologies such as Web 2.0 and Cloud Computing has established relatively new ways for work activities.

Common practices carried out by today organizations, in order to raise its internal levels of collaboration, are usually based in the acquisition of several different commercial software tools. This option can result quick and easy, but it also carries some risks associated with the poor management of human factors related to the nature of computer-mediated collaboration. In this sense, the adoption of different specific purpose tools can lead to an increase of the cognitive load required to perform the work, since a large amount of psychological resources have to be assigned to the management of different heterogeneous interfaces or functional constraints (Arnetz, 1997). This increase in the cognitive needs can in turn conduce to an increase in Occupational Stress levels, diffuse the components of the Organizational Culture, reduce the levels of Organizational Identification, and finally ruin the evolution of the EISs (Shum, 1997).

<table>
<thead>
<tr>
<th>Tool Types</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Communication</td>
<td></td>
</tr>
<tr>
<td>Phone / VoIP</td>
<td>Skype, Asterisk</td>
</tr>
<tr>
<td>Email</td>
<td>Outlook, Gmail</td>
</tr>
<tr>
<td>Chats</td>
<td>GTalk, Sametime, Pidgin</td>
</tr>
<tr>
<td>Instant Messaging</td>
<td>WhatsApp, Line, Telegram</td>
</tr>
<tr>
<td>Videoconference</td>
<td>Netmeeting, Hangouts</td>
</tr>
<tr>
<td>eMeetings</td>
<td>UberConference, Lotus Notes</td>
</tr>
<tr>
<td>ERPs</td>
<td>SAP, PeopleSoft</td>
</tr>
<tr>
<td>Projects</td>
<td>Project, DotProject, Collaborative, Wrike</td>
</tr>
<tr>
<td>Business Processes</td>
<td>Bonita BPM, ARIS, ADONIS</td>
</tr>
<tr>
<td>Workflows</td>
<td>JIRA, BaseCamp, RedMine, Asana, YAWL</td>
</tr>
<tr>
<td>Social Networks</td>
<td>Facebook, Google+, LinkedIn, Yammer, Ning</td>
</tr>
<tr>
<td>Document Management</td>
<td>Documentum, Alfresco, Google Drive, Office 365,</td>
</tr>
<tr>
<td>Workspaces</td>
<td>Log:Meln, TeamViewer</td>
</tr>
<tr>
<td>Modeling</td>
<td>LucidChart, ConceptBoard, Cacao, Diagramly</td>
</tr>
<tr>
<td>Software</td>
<td>GitHub, Cloud9, Koding, CodeAnywhere</td>
</tr>
<tr>
<td>eLearning</td>
<td>Moodle, Chamilo, EDU 2.0, MediaWiki, TiddlySpot, Joomla, Drupal</td>
</tr>
<tr>
<td>Knowledge Management</td>
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4 OUR PROPOSAL

After examining three areas of main interest (CSCW, HCI and PO) closely related to the study of collaboration in EISs in section 2, and reviewing most common tools adopted by organizations from the perspective of Communication, Coordination and Cooperation in section 3, it seems clear that most of the results that have been obtained when studying the presence and effect of human factors in computer-mediated working scenarios, have not been widely analysed. By contrast, due to the proliferation of specific purpose commercial tools, current organizations tend to acquire many tools to partially cover singular lacks, omitting the lacks related to the human factors mentioned above.

Our recent work (Antonaya, 2012) (Antonaya, 2013) has been focused in the development of a framework for the modeling and development of organizational collaborative systems taking Organizational Structures, Business Processes and Workflows, and Groupware Tools as basis. From the results obtained in those works, the human factors and types of tools reviewed in this article, and the associated identified needs, we are currently adapting our work to the field of CNs in order to...
include awareness and social aspects too.

In following sections we discuss the principles of our current line of work: in section 4.1 we expose a summary of our framework for the development of organizational collaborative systems; in section 4.2 we study how to approach the development of CNs in order to facilitate the handling of the human factors that were identified in section 2, as well as to overcome some of the difficulties related to communication, coordination and cooperation that were discussed in section 3; finally, in section 4.3 we present a system called HARMONIA that will help us to validate our proposals.

4.1 Framework

Our framework pretends to harmonize the development of organizational collaborative systems by means of the integration of three domains: Organizational Structures, Business Processes and Workflows, and Groupware. The framework is also divided in a Conceptual Framework and a Technological Framework that ease the modeling of static and dynamic aspects of organizations, and the development of systems from the resultant models by means of Model Driven and Component Based approaches.

4.2 Handling Human Factors

The evolution of EISs in order to handle human and social factors requires the consideration of the three domains of our framework. From this premise, the modeling of organizational systems in terms of networks or graphs can help to tackle with emerging organizational models, and to take advantage from the lessons learned from the use of some of the tools reviewed in section 3. Figure 1 shows the relation between all these concepts:

![Figure 1: Relation between our framework, CNs modeling methods and identified human factors.](image)

4.3 The HARMONIA System

The HARMONIA system is a sample application that illustrates the modeling of structures, workflows and collaborative tools by means of our framework. As stated previously, the main paradigm in which this system is based is Cloud Computing, so that all resources and applications that may be required by members are hosted in the cloud. This model, in turn facilitates a better support for awareness as the status of any element related to the system is accessible from anywhere and at the same time by part of all the members of the working group. Figure 2 shows a screenshot of the HARMONIA system:

![Figure 2: HARMONIA system.](image)

The underlying idea of the HARMONIA system is that a holistic-oriented working environment can help to handle human and social factors in global scenarios, as well as to overcome known harms that come from the ambit of Communication, Coordination and Cooperation. In this sense, it will help us to conclude following ideas:

- **Communication**: a unified working environment facilitates the arrangement and management of communication channels available for the members of the organization.
- **Coordination**: can be transformed from a question that requires active management to something to the activity that is carried out by working groups.
- **Cooperation**: the Cloud Computing paradigm can help to incorporate existing tools or use external APIs in order to help organizations to develop expand existing EISs and maintain high levels of homogeneity, what can in turn help to reduce cognitive demands for users as pointed in section 2. In this sense, it seems especially relevant the possibility of take advantage of development paradigms such as Model Driven or Component Based methodologies.
5 CONCLUSIONS

To provide EISs with adequate support mechanisms for collaboration seems to be quite important in new global working contexts. At the same time, the field of CNs reveals that further study on both human and social factors is required. In fact, the appropriate handling of these factors can critically influence in the success of new systems. In this sense, we have illustrated the use of our framework for the development of organizational collaborative systems from the perspective of CNs, and proposed it as a possible solution for the integration of results obtained in the areas of CSCW, HCI, and PO, in order to promote holistic approaches for the development of collaborative systems, what in turn can become highly valuable for the evolution of traditional organizational software.

ACKNOWLEDGEMENTS

This research has been partially supported by the Ministerio de Economía y Competitividad (Spain) in the TIN2011-29542-C02-02 project.

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