Handling Human Factors in Cloud-based Collaborative Enterprise Information Systems

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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).

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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 1: Human factors.

Factors	Description
Disparity between work and benefit	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.
Motivation for Participation	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.
Cooperation and Altruism	Cooperation processes often require altruistic behaviours by part of participants, although the real motivation for altruistic behaviours has not been clearly identified yet
Organizational Culture	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.
Organizational Identification	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.
Occupational Stress	Poor or hindered communication, diffuse definition of organizational roles and lack of feedback on one-self performance can produce a negative impact on O*ccupational Stress*.
Role Ambiguity	*Role Ambiguity* is the uncertainty about what actions must be taken in order to fulfil the assigned role.

There is a wide range of software tools that can result highly useful in order to apply solutions for factor listed in Table1. 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 2: Collaborative tools.

	Tool Types	Examples
Communication	Phone / VoIP	Skype, Asterisk
	Email	Outlook, Gmail
	Chats	GTalk, Sametime, Pidgin
	Instant Messaging	WhatsApp, Line, Telegram
	Videoconference	Netmeeting, Hangouts
	eMeetings	UberConference, Lotus Notes, Hangouts, Lync
Coordination	ERPs	SAP, PeopleSoft
	Projects	Project, DotProject, Collabtive, Wrike
	Business Processes	Bonita BPM, ARIS, ADONIS
	Workflows	JIRA, BaseCamp, RedMine, Asana, YAWL
Cooperation / Collaboration	Social Networks	Facebook, Google+, LinkedIn, Yammer, Ning
	Document Management	Documentum, Alfresco, Google Drive, Office 365,
	Workspaces	LogMeIn, TeamViewer
	Modeling	LucidChart, ConceptBoard, Cacoo, Diagramly
	Software Development	GitHub, Cloud9, Koding, CodeAnywhere,
	eLearning	Moodle, Chamilo, EDU 2.0,
	Knowledge Management	MediaWiki, TiddlySpot, Joomla, Drupal

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:

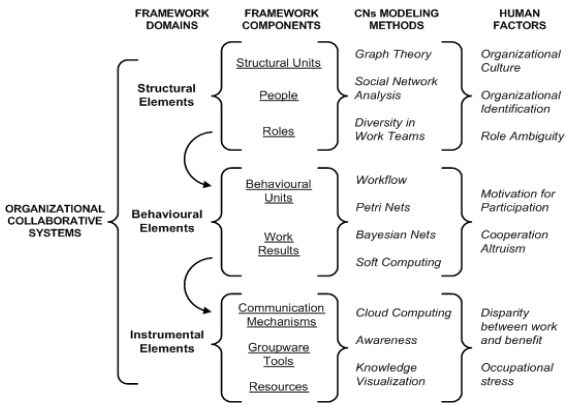

Figure 1: Relation between our framework, CNs modeling methods and identified human factors.

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:

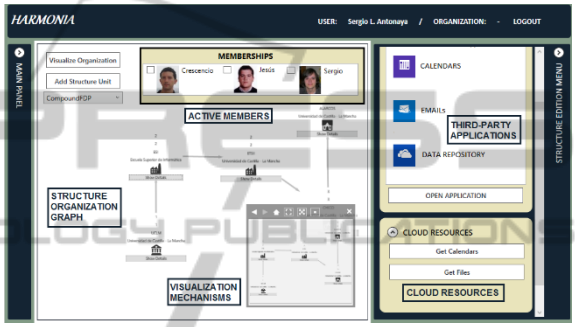

Figure 2: HARMONIA system.

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.

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