Towards an Overarching Classification Model of CSCW and Groupware: A Socio-technical Perspective

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Abstract. The development of groupware systems can be supported by the perspectives provided by taxonomies categorizing collaboration systems and theoretical approaches from the multidisciplinary field of Computer-Supported Cooperative Work (CSCW). In the last decades, multiple taxonomic schemes were developed with different classification dimensions, but only a few addressed the socio-technical perspective that encompasses the interaction between groups of people and technology in work contexts. Moreover, there is an ambiguity in the use of the categories presented in the literature. Aiming to tackle this vagueness and support the development of future groupware systems aware of social phenomena, we present a comprehensive classification model to interrelate technological requirements with CSCW dimensions of communication, coordination, cooperation, time and space, regulation, awareness, group dynamics, and complementary categories obtained from a taxonomic literature review.

Keywords: CSCW, groupware, taxonomy, classification scheme, meta-review, socio-technical requirements, group process support.

1 Introduction

As systems and tools evolve and become more complex, it is much harder to evaluate them with high levels of completeness. Taxonomies provide a way to classify them according to their distinctive characteristics while establishing a basis for discussion and improvement. Commonly understood as “the science of classification”, taxonomy is the assay of the procedures and principles of evaluation, whose terminological genesis is derivative from the words *taxis*, signifying arrangement, and *nomos*, meaning study [1]. Its focus relies on the intelligibility and schematic arrangement of the phenomena through taxonomic units arranged in a classification model or an hierarchical

V. Herskovic et al. (Eds.): CRIWG 2012, LNCS 7493, pp. 41–56, 2012.

structure. For the specific case of systems and tools developed to support group work, several taxonomic approaches were presented in the literature, including technology-oriented or cooperative work dimensions. Partly, this diversity can be justified by the increased complexity with the emergence of new groupware systems, but it is also a reflection of a lack of adequacy and/or scope of existing taxonomies. Grudin & Poltrock [2] argued that CSCW research community leaned forward slightly on the fundamental frameworks developed by Mintzberg and McGrath in the 1980s, and more research is needed to fill the gap between social and techie domains [3], with a better understanding of the nature of collaborative work and the amount of technology features. This view is reflected by the CSCW acronym, which was coined to define two aspects considered then – as now – significant, cooperative work (CW) as social phenomenon that characterizes group work, and computer-supported (CS) in the perspective of collaboration technologies that support it [4]. Currently, CSCW involves nomadic work activities and comprises observable practices such as planning, intellectual co-construction, task management, playing, massively production, mechanical assembly, problem-solving and negotiation, which can be reflected in the 3C model [5]. Groupware, a "sibling" term of CSCW, refers to technology itself and is usually conceptualized as "computer-based systems that support groups of people engaged in a common task (or goal) and that provide an interface to a shared environment" to empower human interaction [5]. It provides a shared space for cooperation and enables awareness among group members, representing an outcome of CSCW research which encompasses sociological features of cooperative work in multiple forms and application fields (e.g., healthcare, learning, military training, tourism, among others). Therefore, these concepts are correlated and occasionally understood as synonymous.

Grudin & Poltrock [2] claim for an evaluation of technology in use on real scenarios (e.g., hospitals, museums and homes) towards a formal theory of CSCW to support new group dynamics with awareness and adaptive mechanisms to the context of labor. However, some difficulties arose to identify system requirements, taking into account the way people work in group, the influence of technology in their activities [6] – and consequently, problems in developing systems that would be based on those requirements. The lack of a standard set of collaboration dynamics and systems is one of the major gaps related to decomposition of collaboration processes in view of subsequent definition of system requirements and specification [7]. Task typologies unfilled in the literature have been applied by matching technology to tasks. Complementarily, collaboration is a phenomenon that can change over time and this fact implies a need to examine the articulation of cooperative work activities [4]. Thus, it would be useful to reformulate prior approaches used in the taxonomic models [8] and develop a classification model to accommodate new systems with increased complexity.

In this paper, we review multiple taxonomies that have been suggested to evaluate CSCW and groupware, ordering them chronologically according to the literature dimensions. Subsequently, a set of evaluation categories is proposed towards a classification scheme that aims to encompass the general requirements of collaboration technologies and cooperative work dynamics, addressing the problem of the lack of standardization. This was accomplished via a content analysis method by searching the main common categories of classification models suggested in the literature. The aim is to bring an holistic and evolutionary perspective highlighting taxonomic categories.

In addition to this introductory section, the structure of this article is subdivided by: a methodological approach used to collect taxonomies; a meta-review of taxonomies proposed to evaluate CSCW and groupware domains, followed by a segment dedicated to the analysis of results; a section with a schematic organization of socio-technical requirements that can support collaboration; and finally, a reflection section constituted by syntactical remarks and future research possibilities based on existing gaps.

2 Methodology

According to Weiseth *et al*. [7], there is a lack of a practical, holistic framework that may conduct organizations and other social entities in their effort to specify, evaluate and acquire collaboration systems that can support their needs. Verginadis *et al*. [9] claims that further research is required to develop or validate ontological structures of collaboration processes for recurring high-value tasks. Emerging collaboration tools require that CSCW research understand the current context, significant effects in society that unfold around successfully implementations [2]. Penichet *et al*. [10] argue that new evaluations are required to fit the current collaboration systems, and Schmidt [11] pointed to the need of a theoretical framework for analyzing or modeling cooperative work and specifying requirements of computer-based systems meant to support cooperative work. There is a need to consider the space within which CSCW research is conducted to create an overarching theory and taxonomy of CSCW and groupware [2]. Due to the lack of systematic reviews with amplitude to cover taxonomic approaches presented in literature, a meta-review process is presented based on the Kitchenham's guidelines [12] to summarize the current background.

The scope of this study relies in re-analyzing the literature references about groupware characteristics at a technological perspective, and collaborative work categories related to the human factors and task dimensions, with the aim to provide a systematic approach surveying and synthesizing prior research in CSCW [13]. Due to their systematic methodological nature, involving a discovery of theory through a data qualitative analysis, Inductive Analysis [14] and Theory for Analyzing [15] support a substantial portion of the present literature review process with a focus on the evaluation model that summarizes information and conveys taxonomic categories.

2.1 Research Questions

In the first methodical compass, a set of Research Questions (RQs) is defined to organize the main proposals of this study:

RQ1. Is a taxonomic background useful to CSCW scientific community? How can it be enhanced according to the technological and group work paradigm shift?

RQ2. How can we fill the gap of an unified taxonomy to CSCW and groupware?

RQ3. How should we distill the socio-technical requirements for cooperative work and groupware systems from literature integrating them into a comprehensive model?

Following the standard systematic literature review method proposed by Kitchenham *et al.* [12], RQ1 can be conceptualized into a temporal context, where last known taxonomic review was carried out by Bafoutsou & Mentzas [16], and other taxonomy-related approaches maintained a similar focus to justify classification categories [e.g., 7, 8, 10]. In this sense, we explore post-2002 references giving a different perspective compared to previous taxonomic review studies, and 'dig' the basics of previous taxonomies related with the main characteristics of group work and support systems. The second question (RQ2) addresses the problem identified in Grudin & Poltrock [2] study, where they argued that "much has been done since McGrath [17] on the nature of tasks performed by groups", and new technological implementations require that CSCW researchers understand the current work context to identify significant impacts on the societal domains. That is, we do not have an unified evaluation model to classify the holistic nature of CSCW research field, and this aspect can be a research opportunity for researchers to learn from the past taxonomic approaches and contribute to the understanding of emerging phenomena at a socio-technical perspective. The third issue (RQ3) relies on the identification of a suitable set of categories to classify socio-technical requirements from literature, launching a research agenda for future studies with a more empirical genesis in psychological, sociological, anthropological, among other domains that characterize the origins of CSCW field [2, 6].

2.2 Search Process and Selection Criteria

The phase of exploratory literature review follows a manual search process to retrieve a set of taxonomy-related scientific articles and books since 1984, not only for being an historical year for the origins of this field [6] but also for representing the course of two landmark studies perpetrated by McGrath [17] and Mintzberg [18], not diminishing similar studies. The set of articles, books and technical reports of our sample were selected by have been used as sources in other review papers [e.g., 2, 16, 19] and as to complement these previous studies with new references in order to achieve an holistic perspective on the taxonomic categories proposed in CSCW and groupware domains.

The selection of studies complied with the process is shown in the Figure 1. First, an inquiry was made for a set of refined search terms in Google Scholar, ACM Digital Library and Web of Science databases (see [20] for a detailed comparison), joining a word sequence constituted by the terms 'taxonomy', 'classification' and 'evaluation', and aggregating them with 'groupware' and 'CSCW'. The search by terms 'collaboration', 'cooperation' and 'coordination' were not totally applied in this study due to its common representation in distinct fields, which can expand this taxonomic universe in the future with a different search approach. In addition, a broad-spectrum reference list was collected and was read their title, abstract or in full, only in the cases in which taxonomic nature was not clear in the abstract. In the case of Google Scholar indexed references, citation count was a selection criterion to organize results as an important bibliometric indicator to this analysis, which was obtained from Google Scholar citation index. A review in the reference list of each publication allowed us to recognize taxonomic studies that were not found in the previous search.

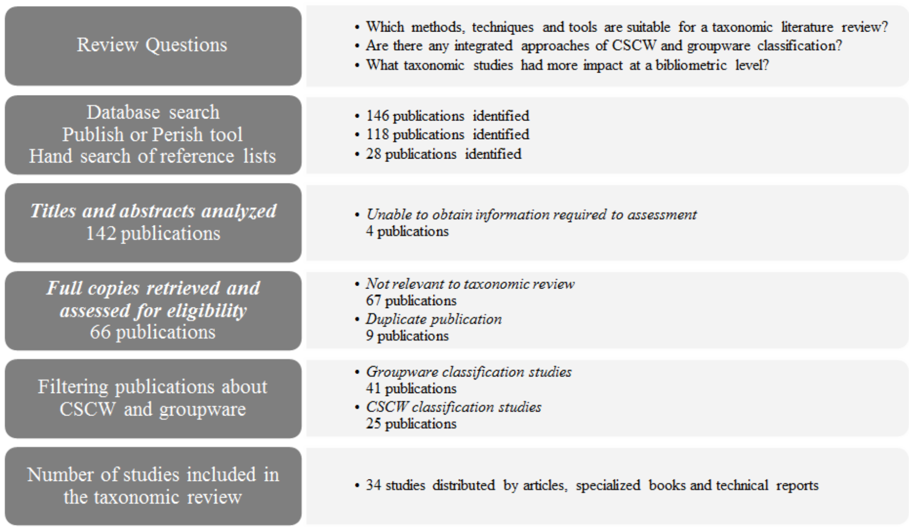

Fig. 1. Flow chart of taxonomic review process

2.3 Data Analysis

Focused literature review stage consisted in the full reading of papers. In this process, a scheme with the taxonomic attributes was developed to organize data about authors, year of publication, work dynamics in collaboration settings (communication, cooperation and coordination), temporal and spatial dimensions, group issues (types of group tasks, characteristics and size), technical categories of groupware applications (scalability, software and hardware), and complementary categories (e.g., usability). In this context, the afore-explained classification scheme supported a study of literature proposals based on the classification dimensions proposed by Bafoutsou & Mentzas [16]. To build this scheme, the previously chosen articles was read and extracted from them a set of core characteristics that were interrelated with reviews proposed in the past.

3 Diggin' the Literature to Find a Context: Taxonomic Anthology

As mentioned above, one of the earliest known taxonomic approaches for the study of groups was conceptualized by McGrath [17]. However, his research route was strongly influenced by significant preliminary studies. Carter *et al.* [21] classified tasks into six distinct typologies: clerical, discussion, intellectual construction, mechanical assembly, motor coordination and reasoning, which were introduced taking into account the group activity but cannot deal with the nature of the task outcome nor the relations between members at a coordination perspective. Meanwhile, Shaw [22] expressed the task complexity dimension, and McGrath & Altman [23] referred a need for systematic conceptual analysis of tasks and their relations to group members, within which the tasks could be classified according to: physical properties; behaviors needed and normally evoked by the task; behavior relationship among group members (e.g., cooperation requirements); and the task goal, criterion and outcome (e.g., minimizing errors).

Subsequent studies produced insights about the behavior requirements of intellectual tasks, specifying classification categories such as decision, production, problem-solving, discussion and performance. According to McGrath [17], the first really programmatic effort to show systematically the distinct characteristics of group tasks was carried out by Shaw [24], surveying them from past published studies of small groups and extracting six categories along which group tasks vary: intellective versus manipulative requirements; task difficulty; intrinsic interest; population familiarity; solution multiplicity or specificity; and cooperation requirements. Driven by the afore-referred visions, McGrath [17] extract the main ideas from literature and fit them together into a conceptually interrelated set of classification dimensions about tasks. The result was a group task circumplex constituted by four quadrants (generate, choose, negotiate, or execute), within which are specific task types: planning, creativity, intellective, decision-making, cognitive conflict, mixed-motive, contests/battles, and performance. In an organizational viewpoint, the model proposed by Mintzberg [18] claims that executives (*strategic apex*), managers (*middle line*), support staff, individual contributors (operating core) and people formulating work processes (*technostructure*) often have different approaches, constraints, opportunities for action or competing priorities [2].

In the groupware domain, one of the first approaches was proposed by Bui & Jarke [25], with a strong focus on communication requirements for Group Decision Support Systems (GDSS). In this approach, a group communication arrangement can be classified with respect to the spatial distance between decision meetings (remote and co-located), temporal distance of the participants (simultaneous and different time), control centralization (democratic or hierarchic), and cooperation degree in meeting settings (cooperation and negotiation). The contingency perspective for GDSS research [26] has three dimensions: i) task type (planning, creativity, intellective, preference, cognitive conflict or mixed motive), ii) member proximity (face-to-face or dispersed), and iii) group size (smaller or larger). Task type distinction was based on McGrath's group task circumplex [17], a vision corroborated by Jelassi & Beauclair [27].

Nunamaker *et al.* [28] proposed a taxonomy that replaced the task type criterion by time. Their scheme also takes into account the number of members of a team or group according to physical proximity and time dispersion. The time/space matrix was suggested by Johansen [29] with focus on the temporal and spatial dimensions. It is mainly concerned with the technological support for group activities, and has four classes relating the time and place of team members' interaction. Grudin [6] brought an extension that adds predictability of place and time to the original matrix.

The taxonomy proposed by Ellis *et al.* [5] highlights the significance of 3C model (communication, coordination and collaboration) in the group interaction support. In their opinion, collaboration is based on information sharing, and coordination is concerned to shared objects access. Similar taxonomies (e.g., [30, 31, 32]) were proposed to interrelate a set of application domains into the 3C model [30], where an evaluation based on modes of collaboration is organized by communication, information sharing and coordination categories, and the collaboration synchronicity degree (real-time or asynchronous) [32]. Ellis & Wainer [31] developed a functional decomposition to the groupware systems taking into account the three dimensions intended to developers whose focus lies on the user interface, specifically: the groupware ontology associated to the data structure; a coordination model that describes the effective management of interaction flow; and an user interface model to help the interaction between the users and system. In the same year, Malone & Crowston [33] proposed a taxonomy of coordination tools, where the focus relies on the supported management process and it is dedicated to management issues, fairly independent of technical features.

Hybrid taxonomies were introduced to associate categories of the central schemes (time/space, 3C model, and application domains), and add new taxonomic elements to categorize the technological and social components of CSCW research. In the taxonomy proposed by Jarczyk *et al.* [34], collaboration systems were characterized by the follow classes of criteria: functional, application, technical, usability, ergonomics and scalability. Mentzas [35] classified the coordination-related aspects of group technology into five categories: coordination model characteristics, type of processing, decision support, organizational environment, and objectives. Completing the evaluative review of Bafoutsou & Mentzas [16], new taxonomies was introduced to provide: i) a categorization of collaboration tools according to the underlying technology [36], ii) task (decomposition and complexity), group (size, composition, leadership, member characteristics, and subject) and technology (task support, tools, mode of communication, process structure, and design) [37], or iii) application-level categories of collaboration tools (e.g., workflow and group decision support) or collaborative services [16]. Basically, the hybrid taxonomies proposed in the literature can give a broad-spectrum classification perspective, integrating the main previously contributions to help programmers, academics and general public to understand collaboration systems.

4 Meta-analysis Results

As mentioned above, Bafoutsou & Mentzas [16] reviewed prior taxonomies presented in literature. Nevertheless, this review left out some studies (e.g., [11, 17, 18, 30, 25, 27, 28, 31, 32, 37, 38]) taking into account the time interval of analysis (1987-2002). The distribution of dimensions is represented within a classification scheme (Table 1), which is supplemented with more categories and taxonomies identified using our own methodical process. The sample of this review is circumspect to the 1984-2009 interval, where the selected criteria is based on the importance of McGrath's research into group tasks domain, and the complementarity to previous studies with a current systematic analysis. The review scheme is constituted by: time/space (which is the most addressed in the Table 1, where collaboration can be synchronous and asynchronous, as well as co-located and remote); CSCW characteristics (based on 3C model); group issues (size, characteristics and task types); technical criteria (scalability, software and hardware); and complementary features (e.g., ergonomics and usability, awareness, or application domains). The CSCW characteristics (such as cooperation, coordination, communication, articulation work, division of labor, among others) are at a similar level of group issues. In fact, they are included in taxonomic proposals since 1991. By a chronological distribution of literature, it can be seen that the interest in 3C model characteristics has grown in the last years. The attention on other aspects was stable, with clear exceptions to group issues, whose interest experiences a notable fall in the last years. Also, a concern with human-computer interfaces is really obvious, with this feature being an important issue. Starting on their specific work, we will take it a step further, adding the dimension of CSCW characteristics, bibliometric indicators, and including both the more recent literature and that they left out from their study. Our contribution is highlighted in bold, giving a perspective of unexplored taxonomies. The study presented here could be expanded by considering aspects such as ‘collaboration patterns’ [39], collaboration needs adapted from Maslow’s hierarchy [40], and classification dimensions suggested by Boughzala *et al.* [41] to evaluate collaborative work and technology support centered on the MAIN+ method, which were not taken into account in the present version but offer improvement possibilities.

Table 1. Distribution of classification dimensions across the literature

Year	Author(s)	CSCW charac-teristics	Time/ Space	Group issues	Technical criteria	Other	Bibliometric indicators¥
1984	**McGrath [17]**			*			2798 citations
1984	**Mintzberg [18]**			*		Organizational Structure	8393 citations§
1986	**Bui & Jarke [25]**		*			Mode of Interaction	52 citations
1987	DeSanctis & Gallupe [26]		√	√			1747 citations
	Jelassi & Beauclair [27]		*			Mode of Interaction	71 citations
	Stefik *et al.* [42]				*	Development/HCI	1033 citations
1988	Kraemer & King [43]			√	√		494 citations
	Johansen [29]		√				801 citations
1991	Ellis *et al.* [5]	*	√			Mode of Interaction; Application-level	2912 citations
	Nunamaker *et al.* [28]		*	*			1590 citations
1992	Jarczyk *et al.* [34]			√	√	Mode of Interaction; Usability/Ergonomics; Application-level	8 citations
1993	Mentzas [35]	*	√		√	Mode of Interaction	32 citations
1994	McGrath & Hollingshead [44]			√			646 citations
	Grudin [6]		√				934 citations
	Malone & Crowston [33]	*		√			2589 citations
	Ellis & Wainer [31]					Development/HCI	228 citations
1995	Coleman [45]					Application-level	132 citations
1997	**Grudin & Poltrock [32]**	*	*				76 citations
1998	**Fjermestad & Hiltz [37]**			*	*	Mode of Interaction; Usability/Ergonomics; Organizational Structure	596 citations
2000	Ellis [36]				√	Application-level	22 citations
2000	**Ferraris & Martel [38]**	*				Regulation	27 citations
2002	**Bafoutsou & Mentzas [16]**		*			Application-level	134 citations
2002	**Pumareja & Sikkel [46]**	*	*	*		Application-level; Awareness Indicators	5 citations
2002	**Andriessen [47]**	*		*		Organizational Structure	6 citations
2003	**Bolstad & Endsley [48]**	*	*		*	Mode of Interaction	17 citations
2004	**Neale *et al.* [49]**	*					165 citations
2006	**Weiseth *et al.* [7]**	*			*		23 citations
2007	**Okada [50]**	*	*	*		Awareness Indicators	0 citations
	Penichet *et al.* [10]	*	*			Application-level	28 citations
	Elmarzouqi *et al.* [51]	*	*			Development/HCI	6 citations
2008	**Mittleman *et al.* [8]**		*		*	Application-level; Awareness Indicators	17 citations
2009	**Giraldo *et al.* [52]**			*		Development/HCI	0 citations
2009	**Golovchinsky [53]**	*	*				26 citations
2009	**Briggs *et al.* [54]**			*	*	Application-level	11 citations

√ Bafoutsou & Mentzas [16] classification dimensions

* Our systematic review’s contribution

¥ Obtained from Google Scholar citation index at 8 April 2012

§ Number of citations related to the first known Mintzberg’s approach

Bolstad & Endsley [48] proposed a classification scheme for collaboration tools intended to support the development of technology and acquisition of material for military purposes (i.e., face-to-face, video/audio conferencing, telephone, network radios, chat/instant messaging, whiteboard, program/application sharing, file transfer, e-mail, and domain specific tools. Moreover, categories are classified as collaboration characteristics (collaboration time, predictability and place, and degree of interaction), technology characteristics (recordable/traceable, identifiable, and structured), information types (emotional, verbal, textual, video, photographic information, and graphical/spacial), and collaboration processes (data distribution, gathering, scheduling, planning, tracking, document creation, brainstorming, and shared situational awareness).

Then, Neale *et al.* [49] proposed a pyramidal scheme for the evaluation of the support provided by collaboration systems to activity awareness. This taxonomy focuses some of the core CSCW characteristics (communication, coordination, collaboration, cooperation, information sharing, and light-weight interaction), linked to contextual factors, distributed process loss, work coupling, common ground, and activity awareness). Subsequently, Weiseth *et al.* [7] suggested a wheel of collaboration tools as a framework constituted by the collaboration environment, process and support, related to the functional areas of coordination (mutual adjustment, planning, standardization), production (mailing, search and retrieval, capturing, authoring, publishing), and decision-making (survey, query, evaluation and analysis, reporting, choice).

In 2007, Okada [50] introduced an hierarchical taxonomy to classify collaboration. From basis to top, it has: coexistence (place and time), awareness (influenced by human, spatial, and temporal factors), sharing (views, opinions, knowledge, operations, and others), and collaboration (cooperation, and assertion). According to the author of this study, the degree of assertion and cooperation shown by the group members influences the outcome of collaboration. Only high levels of assertion and cooperation result in coordination, a higher level of assertion results in collision, and if cooperation is higher than assertion the outcome is concession. Penichet *et al.* [10] considered that most of the taxonomies existing at the time were inadequate to classify more complex systems that include a large variety of tools. They argued that some tools are forced to fit in one category. In fact, these systems can be used in different ways and contexts in a synchronous and asynchronous setting. Thus, they proposed a taxonomy to accommodate some of such situations and interrelate time/space matrix with information sharing, communication and coordination. In the same year, Elmarzouqi *et al.* [51] approached the Augmented Continuum of Collaboration Model (ACCM), which is also focused in the CSCW characteristics (collaboration, cooperation, and coordination), and relating them with ACCM components: co-production, communication, and conversation. In summary, this taxonomy is based on the 3C model, with addition of conversation, regulation and awareness. The Mittleman *et al.*'s [8] taxonomic study includes nine architectural implementations, with a specific granularity, to classify the attributes of groupware systems. This taxonomic effort follows a previous work [55] based on the encapsulation of collaboration patterns to classify collaborative work.

A conceptual framework was suggested for the design of groupware user interfaces [52] with a focus on shared context, visualization area, activity, division of labor, task types, geographical information, people, events, time interval, object, strategy, as well as rules. Following the proliferation of systems and algorithms in industry and academy, it was proposed an evaluation model for collaboration systems at an information seeking perspective [53] with the domains of intent, depth, concurrency, and location. Furthermore, Briggs *et al*. [54] give a social-technical perspective to define "seven areas of concern for designers of collaboration support systems", subdividing them by goals, products, activities, patterns, techniques, tools, and scripts. This classification model represents the starting point for the classification model presented here.

5 Socio-technical Requirements to Support Collaboration

Taxonomic proposals of CSCW and groupware are varied, with a fair amount of differences. Penichet *et al*. [10] argued that one of the main reasons to this variety relies on the increased complexity of groupware tools. An overarching classification model is proposed to categorize collaboration requirements for a more social-oriented groupware development. According to Johnson [56], the creation and refinement of classification systems and taxonomies are crucial processes in theory development, where the categories of a classification model should be mutually exclusive, exhaustive, and logically interrelated. The socio-technical classification model proposed here attempts to bring a *continuum* of collaboration dimensions, which problem relies on the lack of standardization of categories proposed in literature without terminological consensus. In the Figure 2 are shown socio-technical requirements for collaboration, organizing a set of categories taken from literature. The model intends to tackle the evident lack of consensus concerning to the conceptual structure of cooperative work and groupware at a combined perspective, comprising technical requirements and work dimensions in an unified classification model. The taxonomic elements of the scheme presented here are fully based in CSCW and group generic literature, which was extracted taking into account their temporal persistence, bibliometric impact, complementarity, and logical consistence. The "blocks" and "meta-blocks" of this model establish a set of domains according to their granularity, being structured at an hierarchical way.

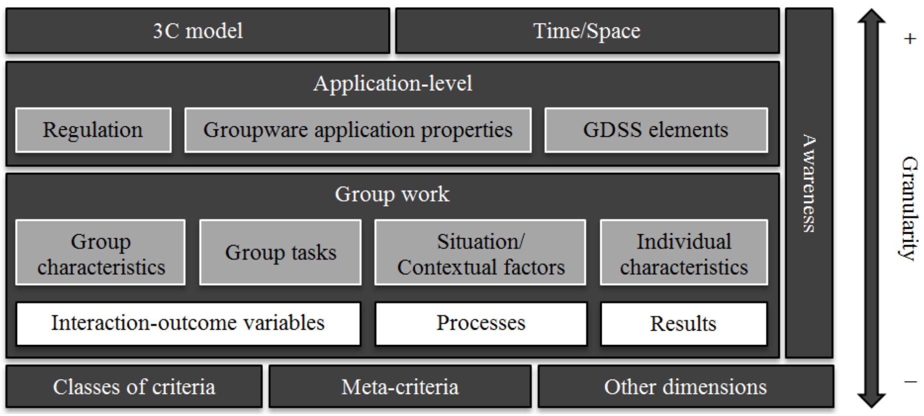

Fig. 2. Socio-technical classification model of CSCW and groupware

The first category of this literature-based classification model is the *3C model*. This category can be systematized into an interactive cycle through the well-known modes of collaboration. *Communication* can be understood as an interaction process between people [17], involving explicit or implicit information exchange, in a private or public channel. The users' messages can be identified or anonymous, and conversation may occur with no support, structured or intellectual process support, with associated protocols. As a requirement, groupware needs to be able to support the conversation between two or more individuals, in an one-to-one, one-to-many or many-to-many setting. *Coordination* was defined by Malone & Crowston [33] as management of interdependencies between activities performed by multiple actors, which are based on the mutual objects that are exchanged between activities (e.g., design elements, manufactured parts, or resources). Some categories related to the coordination in the literature are: planning, control models, task/subtask relationship and information management, mutual adjustment, standardization, coordination protocol, modes of operation, and so on. In order to effectively support coordination, groupware needs to fulfill three important requirements: time management, resources, or shared artifacts produced along the activity chain. *Cooperative work* arrangements appear and dissolve again. Oppositely to conflict [17], cooperation occurs when a group works toward a common goal [33] with high degrees of task interdependencies, sharing the available information by some kind of shared space [6]. Cooperation categories can range from production (co-authoring), storage or manipulation of an artifact, to concurrency, access or floor control. Technologically, cooperation is supported by systems with capabilities to send or receive messages, synchronously and/or asynchronously [8, 35], and also develop or share documents [32], which are identified as requirements in socio-technical classification model. Furthermore, this terminology was adopted by representing a predominant view in CSCW field, although not totally agreed by some researchers.

Collaboration can occurs in a specific time (synchronous and/or asynchronous) and place (co-located or remote), and may have high or low levels of predictability. If we granulize the *Time/Space* category, a set of subdomains can be distilled, more precisely: session persistence, delay between audio/video channels, reciprocity and homogeneity of channels, delay of the message sent, and spontaneity of collaboration. Complementary, it can be useful to define contextual issues to improve work dynamics.

In order to cooperate in the current polymorphic settings, group members must be aware of other's activities, creating group *awareness* at the workspace. The collaboration cycle is bounded by awareness, which is the perception of group about what each member develops, and the contextual knowledge that they have about what is happening within the group [8]. In this sense, awareness mechanisms are essential in collaboration systems to reduce work losses. It characterizes space and atmosphere, activity, object, human, and meta-dimensions such as presence, influence, and abilities.

The *application-level* category identifies a set of typologies for groupware systems. Mittleman *et al.* [8] proposed several categories and subcategories to classify collaboration technology according to its focus on the group level, covering work over a period of time: i) jointly authored pages (conversation tools, polling tools, group dynamics, and shared editors); ii) streaming technologies (desktop/application sharing, audio conferencing, and video conferencing); iii) information access tools (shared file repo-sitories, social tagging systems, search engines, and syndication tools); and iv) aggregated systems. Complementary, a large set of meta-domains can be extensively identified (e.g., message systems, information sharing technologies, GDSS, project, virtual workspaces, meeting minutes/records and electronic meeting rooms, process or event management systems, chat/instant messaging, notification systems, group calendars, collaboration laboratories, bulletin boards, data mining tools, e-mail, workflow systems, intelligent agents, and so on. In this sense, a lack of consensus about groupware domains is a serious challenge to overcome. As a subcategory of groupware systems, *regulation* means the representation of mechanisms that enable participants to organize themselves into a shared environment, where the regulation of collaboration activities concerns the definition and evolution of work rules to ensure conformity between the activity and group goals [38]. It is worth noting that some of the regulation dimensions achieved from literature are: arenas (location); actors (roles, places, and positi-ons); tools (regulative or not); roles (thematic or causal); rules (constraints, norms, or work rules); types of interaction; interactive scenarios; and objects (means of communication and product of collaboration). The *groupware application properties* can be constituted by functional properties of collaboration tools: architecture, functional and quality properties, group processes support, collaboration interface (portal, devices, or physical workspace), relationships (collection, list, tree, and graph), core functionality, content (text, links, graphic, or data-stream), supported actions (receive, add, associate, edit, move, delete, or judge), identifiability, access controls, alert mechanisms, intelligent/semi-intelligent software components, awareness indicators, and platform. *GDSS elements* can include hardware, software, organizationware and people support.

Groups can be defined as "social aggregations of individuals" with awareness of its presence, conducted by its own norms, and supported by task interdependencies towards a common goal in a shared purpose or work context [46]. In this sense, a group is constituted by particular characteristics, such as: size (3 to 7, >7), composition, location, proximity, structure (leadership and hierarchy), formation, group awareness (low or high, and cohesiveness), behavior (cooperative or competitive), autonomy, subject, and trust. The *group members* have a personal background (work experience, training, and educational), skills, motivation, attitude towards technology, previous experience, satisfaction, knowledge, and personality. According to McGrath [17], *group tasks* can be subdivided in creativity, planning, intellective, decision-making (choosing, evaluation and analysis, search, report, and survey), cognitive-conflict, mixed-motive, contests/battles/competitive and performances/psychomotor, having a specific complexity associated to each task. The subcategories can be supported by cultural impact, goals, interdependency or information exchange needs, bottlenecks, or process gain and loss. The *contextual* or *situational factors* can range from organizational support (rewards, budget, and training), cultural contexts (trust or equity), physical setting, environment (competition, uncertainly, time pressure, and evaluative tone), and business domain at an organizational way. Interaction variables are related to group factors: i) *interaction outcome variables*, such as group outcomes (quality of group performance, collaboration processes, and group development), individual outcomes (expectations and satisfaction on system use, appreciation of group membership, and individual breakdowns in system use), and system outcomes (enhancements and affordances); ii) *processes*, including individual, interpretation, motivation and performance dimensions; and iii) *results*, specifically individual rewards, group vitality, and organizational results).

The independent variables are focused on *classes of criteria* (functional, technical, usability, and ergonomics), *meta-criteria* (scalability, and orthogonality) and *complementary dimensions* without a specific domain. Some of the other dimensions that can characterize a socio-technical collaboration scenario are: work coupling, shared tasks and goals, information richness and type, control centralization, activities, division of labor, patterns, techniques, scripts, assistance, learning monitoring, interaction degree, assertion, events, strategy, social connectivity, content management, process integration, sharing (view/opinion, knowledge/information, and work/operation), protection, distributed processes loss, or depth of mediation. However, categories such as accessibility are partially forgotten from CSCW literature studies.

6 Conclusions and Future Work

This paper concludes that there are, in fact, common dimensions to the several taxonomies addressed by literature with more or less regularity. The growth of importance of CSCW characteristics, in opposition to categories such as group issues, might suggest a relation between them. The 3C model is well accepted, widely used, and extremely useful to classify collaboration settings. A literature review leads us to establish requirements solid enough to characterize existing tools or group work dynamics, and the development of new ones. Some taxonomies (e.g., [5, 17]) have an high number of citations at a bibliometric level, which reflects the importance of organizational and group work dynamics, application-level, 3C model, and time/space. Oppositely, it is approached the studies of Okada [50] and Giraldo *et al.* [52] without citations.

A collaboration project can fail due to the lack of literature-based and/or empirical studies about requirements and satisfactory practices. Theories, principles or conceptual frameworks provided by psychology, sociology or anthropology in work contexts can improve group work [46]. The socio-technical classification model can reproduce a mutual adaptation process between groupware and people observable from a collaboration perspective. A key contribution of this paper is to provide a systematic review of how groupware and work settings have been presented in CSCW literature. In this context, this work relies on a community-centered building model with literature support to understand the complex taxonomic phenomena, expanding and adapting existing approaches to create taxonomies and design a contemporary classification model. Organizations, academies, industries and other social entities can apply this model to retrieve insights about collaboration dynamics and improve the quality of interaction.

In future, the literature classification can be done under a more detailed framework, where the taxonomic dimensions would be subdivided in several features. This aspect could help to find the functional requirements of groupware tools, making a step forward towards a more wide and consensual taxonomy of CSCW and groupware. There is a need to translate these theoretical propositions into practical guidelines using a set of methods such as semi-structured interviews or ethnography to find evidences about current virtualized work practices, breaking the ‘tunnel effect’ of CSCW terminology.

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