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E-Collaboration Concepts, Systems, and Applications

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INTRODUCTION

The need to support collaboration among users for the facilitation of everyday tasks, communication, work, and training has been identified since the early stages of computer usage. This need became more critical when computer networking became available. The wide expansion of computer networks, the Internet, and the World Wide Web are some of the main reasons that have accelerated the creation of applications, technologies, standards, and systems that can support communication and e-collaboration. These technologies along with the wide expansion of the Internet led the application designers to rethink the way of exploiting information and communication technologies (ICT) for supporting groups of users. This fact has affected the design and the provision of e-collaboration services, which allows geographically dispersed users in companies and/or organizations to communicate and collaborate in order to learn (computer supported collaborative learning—CSCL) or to work (computer supported collaborative work—CSCW) together.

Today there are many tools, standards, and technologies available that could be used for developing collaborative systems and applications according to the end users' requirements and specific needs.

E-collaboration is an important research topic with a great number of researchers contributing on many aspects. The main reason for this major research activity is the broad topic's scope, which involves not only technological but also social and psychological issues. As a result, there are multiple interpretations about what e-collaboration is. More specifically, we definitely can say that e-collaboration has been defined

in many ways in the past, and the number of definitions has grown recently. The next section presents the main terms in this area.

BACKGROUND

With the development of new technologies, and particularly ICTs, teams have evolved to encompass new forms of interaction and collaboration. This team could be called virtual teams. As defined by Lipnack and Stamps (1997) a **virtual team**, like every team, is a group of people who interact through interdependent tasks guided by a common purpose. Unlike conventional teams, a virtual team work across space, time, and organizational boundaries with links strengthened by webs of communication technologies. The members of virtual teams can collaborate and cooperate in order to interact with each other. Collaboration and cooperation are very similar terms and they are often used interchangeably. **Collaboration** is the act of working together on a common task or process. **Cooperation** is the joint operation toward a common goal or benefit. Biuck-Aghai (2003) stated that we can better understand the difference between collaboration and cooperation by considering their antonyms: the antonym of collaboration is "working independently," while that of cooperation is "competition." Therefore, we think that collaboration is a better term to describe the mode of interaction among the members of virtual teams.

According to the previous, we can consider the broad and descriptive term of **virtual collaboration** introduced by Biuck-Aghai (2003), which is defined as

collaboration, which is conducted without face-to-face interaction, enabled by technology.

A similar definition has been introduced by Kock, Davison, Ocker, and Wazlawick (2001), who stated that e-collaboration is “collaboration among individuals engaged in a common task using electronic technologies.”

This broad definition regards e-collaboration as a term, which is not limited to computer-mediated communication (CMC) or CSCW. CSCW is computer-assisted coordinated activity carried out by groups of collaborating individuals. So it should be clear that CSCW is a generic term, which combines the understanding of the way people work in groups with the enabling technologies of computer networking and associated hardware, software, services, and techniques. Until the introduction of CSCW, the majority of computer systems were based on the wrong hypothesis that the persons work alone and there is no reason to use systems that could support their collaboration. Kock and Nosek (2005) believe that e-collaboration should be a broad term because many other electronic technologies that are not (strictly speaking) computers and that can be used to support collaboration among individuals engaged in a common task. According to this definition, e-collaboration may take place without any CMC or CSCW.

We could agree with this definition. However, we can say that today we observe a trend where the communication devices are (in a broad sense) computers—either they are personal computers (PC), mobile phones, or embedded systems and portable devices. Furthermore, the most instances of e-collaboration involve computers and computer networks and also the trend today in tele-communication networks is to go on all-IP networks.

Therefore, in this article we focus on **e-collaboration** defined as “collaboration, which is conducted without face-to-face interaction among individuals or members of virtual teams engaged in a common task using ICT.”

Groupware (or collaborative software) refers to application software that integrates work on a single project by several concurrent users at separated workstations. Groupware is software that accentuates the multiple user environments, coordinating and orchestrating things so that users can “see” each other, avoiding the conflicts with each other. Groupware is distinguished from common software by the basic as-

sumption it makes: groupware makes the user aware that he or she constitutes a member of a group, while the majority of other software seeks to hide and protect users from each other.

E-COLLABORATION CONCEPTS, SYSTEMS, AND APPLICATIONS

As implied from the definitions presented in the previous section, e-collaboration is a very complex topic and there is a definite need to shape e-interaction to avoid chaos and failure in virtual teams. The shaping of e-interaction in order to support e-collaboration involves not only technological but also social and psychological issues. This issues, useful concepts and as well as useful architectures, systems, protocols, and standards for the development and the support of e-collaboration are presented in this section.

Concepts and Issues for E-Collaboration

Collaboration, with respect to information technology, seems to have many aspects. Understanding the differences in human interactions is necessary to ensure the appropriate technologies are employed to design and develop groupware systems that could support e-collaboration effectively. As presented in Wikipedia (2006), there are three primary ways in which humans interact: conversational interaction, transactional interaction, and collaborative interaction:

- Conversational interaction is an exchange of information between one or many participants where the primary purpose of the interaction is discovery or relationship building. Communication technology such as telephones, instant messaging, and e-mail are generally sufficient for conversational interactions.
- Transactional interaction involves the exchange of transaction entities where a major function of the transaction entity is to alter the relationship between participants. Transactional interactions are most effectively handled by transactional systems that manage state and commit records for persistent storage.
- In collaborative interactions, the main function of the participants’ relationship is to alter a collaboration entity. The collaboration entity is in a

relatively unstable form. Examples include the development of an idea, the creation of a design, and the achievement of a shared goal. Therefore, real collaboration technologies deliver the functionality for many participants to augment a common deliverable. Record or document management, threaded discussions, audit history, and other mechanisms designed to capture the efforts of many into a managed content environment are typical of collaboration technologies.

Research on e-Collaboration in order to satisfy the need for collaboration and collaborative work tries to resolve the following key issues: group awareness, multi-user interfaces, concurrency control, communication and coordination within the group, shared information space, and support of a heterogeneous, open environment, which integrates existing single-user applications.

Biuck-Aghai (2003) refers that two main challenges of e-collaboration are the following:

- How can one know how to carry out collaboration virtually?
- How can one know what is, and has been, “going on” during virtual collaboration?

These challenges could be satisfied by the features of collaborative software presented by Cerovsek and Turk (2004) in order to support sharing. These features are the following:

- Information sharing, which includes different types of information that must be interpreted by human
- Knowledge sharing, which is one of the processes in knowledge management framework apart from knowledge creation, knowledge organization/storage, and knowledge application
- Application sharing, which implies sharing of code or making applications available: categories of sharing are: code, components, applications, services, computing
- Workspace sharing, which provides a virtual space (shared workspace) allocated for employees’ work (as in an office) and may include the sharing of several all previous levels of sharing
- Resource sharing, which includes all kinds of sharing previously listed, as well as the sharing

of other resources such as computing resources, processor time, equipment, and so forth

E-collaboration systems are often categorized according to the time/location matrix using the distinction between same time (synchronous) and different times (asynchronous), and between same place (face-to-face) and different places (distributed). Another categorization of the collaboration technologies has been introduced by Poltrock (2002) and it is based on time-interaction criterion (i.e., synchronous and asynchronous). According to this categorization, groupware can be divided into three categories depending on the level of collaboration:

- Communication tools, which send messages, files, data, or documents between people and hence facilitate the sharing of information; examples of synchronous tools in this category are audio/video conferencing, telephone, textual chat, instant messaging, and broadcast video; examples of asynchronous tools in this category are e-mail, voice mail, and fax
- Collaboration/conferencing tools that also facilitate the sharing of information, but in a more interactive way; examples of synchronous tools in this category are whiteboards, application sharing, meeting facilitation tools, and collaborative virtual environments; examples of asynchronous tools in this category are document management tools, threaded discussions, hypertext, and team workspaces.
- Collaborative management (coordination) tools, which facilitate and manage group activities; examples of synchronous tools in this category are floor control and session management; examples of asynchronous tools in this category are workflow management, case tools, project management tools, as well as calendar and scheduling tools

Architectures for E-Collaboration Systems

As previously mentioned, e-collaboration systems can be either asynchronous or synchronous. Regarding the tools and architectures for asynchronous systems of collaboration from distance, the tendency nowadays is the use of technologies of Web-based systems in which asynchronous services and tools such as electronic

Figure 1. Peer-to-peer topology

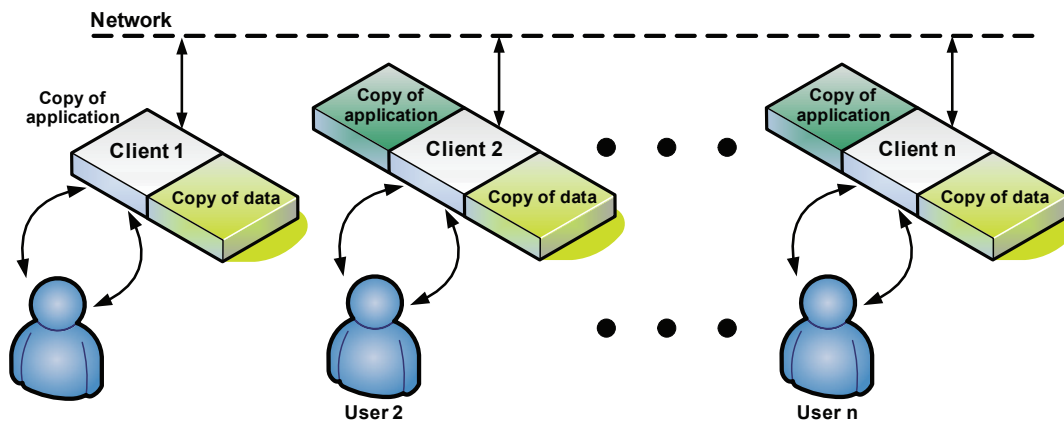
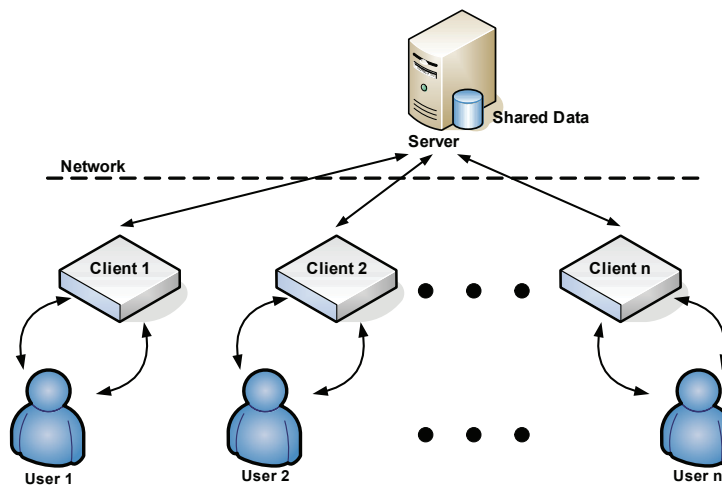


Figure 2. Client-server topology



post, group calendars, and forums are incorporated. In particular, nowadays the tendency turns to the direction of developing collaborative portals. The basic technological solutions for the development of Web-based systems are (a) 3-tier architectures with use Web server, a database, and a scripting language; and (b) N-tier architectures with the use application servers, databases, and modules that allow the development of presentation independent applications in multiple levels.

As far as it concerns the synchronous e-collaboration systems, it should be noted that these systems present great interest due to the advanced sense of realism they aim to achieve. Generally speaking, the communication

among participating workstations in a collaborative session could be supported by using various network architectures with different characteristics. To this direction the architectures that support these types of systems usually fall into one of the following cases: (a) **client-server architectures** (Figure 2), where the clients communicate their changes to one or more servers and these servers, in turn, are responsible for the redistribution of the received information to all connected clients and (b) **peer-to-peer architectures** (Figure 1), where the clients communicate directly their modifications and updates of the world to all connected clients. The case of the client-server model is the most simple but it is cannot support high scalability as there is a central

point of failure, the server. As far as it concerns the peer-to-peer model, the scalability is restricted by the network. Greenberg and Roseman (1999) refer to the previous network topologies also as replicated (peer-to-peer) and centralized (client-server).

Technologies and Standards for E-Collaboration Systems

This section presents useful technologies, standards, and protocols for the development and support of e-collaboration systems. These standards and systems could be categorized in the following categories:

- **Standards and technologies for peer-to-peer systems:** The main standards are: (a) instant messaging and presence protocol (IMPP) (<http://www.ietf.org>) and JXTA (<http://www.jxta.org>).
- **Standards and technologies for videoconferencing applications:** The main standards and protocols for supporting tele-conference and voice over IP (VoIP) services are: (a) eXtensible messaging and presence protocol (XMPP) for supporting text chat functionality; (b) T.120 (<http://www.itu.int>) series of recommendations which collectively define a multipoint data communication service for use in multimedia conferencing environments; (c) H.323 (<http://www.itu.int>), which describes terminals and other entities that provide multimedia communications services; and (d) session initiation protocol (SIP), which supports user sessions that involve multimedia elements such as video, voice, instant messaging, online games, and virtual reality.
- **Real time protocols:** They support real time multimedia transmission, multimedia transmission over the Internet, and quality of services. Examples are RSVP (resource reservation protocol) and RTP/RTCP (real-time transport protocol/real-time transport control protocol).
- **Protocols for collaborative virtual environments:** They are protocols that can support the communication in collaborative virtual environments. Examples are DWTP (distributed worlds transfer and communication protocol) (Broll, 1998; Diehl, 2001), ISTP (interactive sharing transport protocol) (Waters, Anderson, & Schwenske, 1997), VIP (VRML interchange protocol) (Teraoka & Tokoro, 1993), VRTP (virtual reality

transfer protocol) (Brutzman, Zyda, Watsen, & Macedonia, 1997), and DIS (distributed interactive simulation) (Zeswitz, 1993).

Integrated E-Collaboration Systems

According to Mandviwalla and Khan (1999, p. 245), a collaborative technology is integrated if it combines support for more than one mode (e.g., synchronous or asynchronous), medium (e.g., text, graphic, audio, video, shared whiteboard, etc), and structure (i.e., the support provided by the application for group development and productive outcomes). Following this definition, Munkvold & Zigurs (2005) presented seven categories of e-collaboration systems (collaborative product suites, collaborative portals, desktop conferencing systems, Web-based team/project rooms, collaboration peer to peer systems, electronic meeting systems, and e-learning systems). We propose to add another one category titled: collaborative virtual environments, which refers to 3D-based e-collaboration tools.

According to the previous categorization, the following paragraph presents examples of collaborative tools included in each category as well as products and research prototypes that could be categorized there:

- Collaborative product suites include tools such as e-mail, group calendar, threaded discussions, document management, and workflow. Examples are Lotus Notes/Domino, Microsoft Exchange, and GroupWise (Novell).
- Collaborative portals include tools such as instant messaging, presence awareness, team workplaces, people finder, e-meetings, and document management. Examples are IBM Websphere portal, and MS Sharepoint.
- Desktop conferencing systems include tools such as instant messaging/chat, audio conferencing, presence awareness, videoconferencing, application sharing, shared whiteboard, polling, voting, and recording of meeting information. Examples are MSN Messenger, Interwise, Centra 7, WebEx Meeting, Microsoft Live Meeting, and Virtual Room Videoconferencing System (VRVS).
- Web-based team/project rooms include tools such as group calendar, contacts, notes, tasks, file sharing, e-mail, chat, pinboard, project management, document management, threaded discussions, brainstorming, voting, time sheets, telegram,

- evaluation, and scheduler. Examples are TeamSpace, Documentum eRoom, ConferenceXP, and Lotus Workplace Team Collaboration.
- Peer to peer systems include tools such as include tools such as instant messaging/chat, presence awareness, threaded discussion, file sharing, project management, group calendar, group outliner, and meeting management. An example is the Groove Virtual Office.
 - Electronic meeting systems include tools such as include tools such as agenda, brainstorming, categorization & organizing, voting and prioritizing, action planning, surveys, shared whiteboard, meeting log, and chat. Examples are GroupSystems, Facilitate.com, and Meetingworks.
 - E-Learning systems include tools such as e-mail, instant messaging, presence awareness, calendar, threaded discussion, learning objects repository, and course administration. Examples are Blackboard, Centra 7, Aspen, Lotus Workplace Collaborative Learning, WebEx Training Center and Moodle.
 - Collaborative Virtual Environments include tools such as user representation by avatars, presence awareness, text chat, audio chat, intelligent agents, bubble chat, 3D representation of the collaborative space. Examples are Flash Communication Server MX, Blaxxun, ActiveWorlds, Parallel Graphics, and Adobe Atmosphere.

FUTURE TRENDS

The new e-collaboration systems tend to be integrated in at least four dimensions: users and group members, collaboration processes, technologies, and application areas, in order to lead into a suitable e-collaboration platform, which will provide support and openness for all mentioned aspects as explained next:

- From a user-centric point of view, next generation e-collaboration environments have to deliver “quality of experience” and support the presence of other users.
- New e-collaboration environments tend to provide seamless integration of synchronous and asynchronous communications and maintain the user experience in both connected and disconnected modes.

- From a technique-centric point of view, next generation e-collaboration environments should be based on flexible service components which will allow adaptability and scalability. Furthermore, haptic devices and augmented reality platforms will be used the next years for supporting e-collaboration.
- From the application-centric and process-oriented point of view, collaborative ICT technologies have to be customizable to different communities.

CONCLUSION

Recent trends in computing research and the availability of inexpensive computing and communication technology have encouraged the development of e-collaboration environments. Such distributed collaboration is already changing the way business and research is conducted. Nowadays, there is a variety of tools available based on different technologies and offering a wide variety of functionality. The next years we can say that the new e-collaboration systems will be integrated in at least four dimensions: users and group members, collaboration processes, technologies, and application areas, in order to lead into a suitable e-collaboration platform, which will provide support and openness.

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KEY TERMS

Collaboration: Collaboration is the act of working together on a common task or process.

Cooperation: Cooperation is the joint operation toward a common goal or benefit.

CSCW: Computer-supported cooperative work or CSCW is computer-assisted coordinated activity carried out by groups of collaborating individuals.

E-Collaboration: E-collaboration defined as “collaboration, which is conducted without face-to-face interaction among individuals or members of virtual teams engaged in a common task using information and communication technologies.”

Groupware: Groupware is software that accentuates the multiple user environments, coordinating and orchestrating things so that users can “see” each other, yet do not conflict with each other.

Integrated Collaborative Technology: A collaborative technology is integrated if it combines support for more than one mode (e.g., synchronous or asynchronous), medium (e.g., text, graphic, audio, video, shared whiteboard, etc.), and structure (i.e., the support provided by the application for group development and productive outcomes).

Virtual Collaboration: Virtual collaboration is defined as collaboration, which is conducted without face-to-face interaction, enabled by technology.

Virtual Team: Virtual team, like every team, is a group of people who interact through interdependent tasks guided by a common purpose. Unlike conventional teams, a virtual team work across space, time, and organizational boundaries with links strengthened by Webs of communication technologies.