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*An Exploration of Virtual Collaboration and the  
Implications for Open-Source*

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# An Exploration of Virtual Collaboration and the Implications for Open-Source Software

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## Abstract

*This paper explores the process of collaboration in virtual environments. Virtual collaboration relies heavily on electronic media and precludes the benefits of face-to-face contact; yet it offers immense opportunities. The aim of this paper is to provide new perspectives on current research and highlight the key issues that require further investigation. Drawing from the available literature we explore how collaboration has progressed from co-located to virtual settings and we provide suggestions for dealing with the existing challenges. In this context, we will also examine how open-source software can be a viable tool for improving virtual collaboration practices.*

**Keywords:** Virtual Collaboration; Collaborative Technologies; Open-Source Software; Computer-Supported Cooperative Work (CSCW); Distributed Work;

## 1. INTRODUCTION

Unquestionably the arrival of the Internet and other communication and collaboration technologies has enhanced collaboration activities. Organisations and groups of people that transcend time, space, and cultures can now collaborate through innovative applications and technologies (Robey et al., 2000). In the context of innovative application development Open-Source Software (OSS) needs to be further explored as it has recently proven to be highly innovative. Open-source software now competes with software developed in commercial firms in terms of reliability and performance. Even though the virtual environment imposes limitations due to the absence of face-to-face interactions virtual collaboration initiatives achieve outstanding results due to the support from such open-source systems (Yamauchi et al, 2000).

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Recent developments in the field of Computer-Supported Cooperative Work (CSCW) show that technology can dramatically transform the way we learn, work, and collaborate. CSCW delivers innovation and flexibility. Easier access to information, increased participation and collaboration and efficient knowledge sharing are only some of the benefits. The practical importance and potential of collaborative technologies has launched several initiatives for supporting virtual groups of people who seek flexible and ubiquitous collaboration. The central focus of CSCW research is on coordination-intensive processes which mainly involve geographically dispersed people.

There is a growing body of research on the applications and challenges of collaborative systems. Notions such as virtual collaboration (Furst et al., 1999; Qureshi and Vogel, 2001; Qureshi and Zigurs, 2001; Majchrzak et al., 2005) and new ways of working (Wynarczyk, 2005; Hill et al., 1996; Hill et al., 2003; Riedmann et al., 2006) have become commonplace. The most obvious connection between these notions is probably the level of flexibility they offer compared to conventional, non-technology-mediated ways of working and learning. Computer-Mediated Communication (CMC) is the centre of attention for many organisations. As a consequence, various collaboration systems that employ novel information and communications technologies have surfaced.

Even though the concepts behind video-conferencing, net-meetings, shared applications, forums and intranets have been around for the last 20 years or so (Olson and Olson, 2000) it is only recently they were fully commercialised allowing people to realise their full potential. Every-day, work environments are undergoing a 'virtualisation phase' allowing people to manage relationships, share knowledge and expertise and coordinate joint activities in entirely new ways. Collaborative technologies ranging from video-conferencing and electronic meeting systems to information repositories and project management tools allow people to bring dispersed skills on collective ventures that span geographical boundaries. Alongside the changing social and organisational norms, these technologies have matured considerably over the past few years, becoming more cost-effective and readily available. Especially with the recent popularity of open-source software there are

tremendous opportunities to limit the costs and increase the reliability of these technologies. The greatest benefit of open-source systems however is the reduced time span between the conceptual development and the release of a system.

Despite these research efforts and the vast technological progress however, in some situations the technology still fails to meet people's expectations. According to some scholars this has both social and technological implications. From the social point of view, people are not motivated to use the technology due to lack of trust or incentives (Olson and Olson, 2000, Qureshi and Zigurs, 2001, Furst et al., 1999). Motivation plays a key role in the success of collaboration practices, especially in technology-mediated settings. Another challenge is that group members often come from diverse backgrounds, with different cultural values and communication norms. This hinders the process of developing mutual understanding and building a common ground (Cramton, 2001; Rosenberg, 2001).

From the technical viewpoint, there seems to be a long time interval between the inception and implementation of appropriate systems. This is a case where open-source systems could be useful. Other technical problems include compatibility issues, limited bandwidth, and lack of training. As Brown and Duguid (1991) suggest "ethnographic studies of workplace practices indicate that the ways people actually work usually differ fundamentally from the ways organizations describe that work in manuals, training programs, organizational charts, and job descriptions". Finally, some work activities require richer media than others, and different people in the group may feel comfortable with different types of tools. So there is the issue of selecting the most appropriate tools and modes of interaction for achieving effective collaboration (Kock et al., 2007).

According to Furst et al. (1999, p.267) "We know a great deal about the technical aspects of being virtual. We now need to know more about making the human collectivity, the teams, more virtuous". Despite the efforts in the field of CSCW, there is something special about the nature of jointly-produced work practices that we have not yet fully understood. There are yet many aspects to be considered in order to fill this research gap.

The study will explore both the successes and challenges of collaborative systems in terms of enhancing collaboration practices. From the studied literature it is evident that endeavours which incorporate the benefits of face-to-face interaction with those of virtual interaction have more possibilities at succeeding. However, most of the available studies and theories consider only a subset of the prominent attributes of virtual collaboration. This presents a genuine need for evaluating the current collaborative technologies for finding the pre-eminent combination of attributes that will provide the maximum malleability as well as inspire people to use collaborative technologies to work together more productively. The following sections attempt to identify and accumulate the relevant issues covered in the literature. Most importantly, it will propose methodical processes for overcoming the challenges and capitalising the benefits of virtual collaboration.

## **2. FROM CO-LOCATED TO VIRTUAL COLLABORATION**

Despite the widespread use of groupware and collaborative technologies over the last decade some issues have been repeatedly identified by a various researchers. A major issue is the importance of face-to-face communications and the implications involved due to its absence in virtual environments. The most common discussion involves face-to-face versus computer-mediated communication, in which case there are two main communities. The first one suggests that virtual communities can surpass the possibilities engaged in face-to-face teamwork and they can thrive despite physical distance (Robey et al., 2000; Smith, 2000). On the other hand, some researchers believe that distance still matters (Olson and Olson, 2000; Jarvenpaa and Leidner, 1999) and that face-to-face teams outperform virtual teams ((Warkentin et al., 1997).

Other researchers consider virtual teams as an oxymoron, claiming that teams begin to lose their identity and explicitness as they move away from face-to-face interaction (Qureshi and Vogel, 2001). According to Olson and Olson (2000, p.140) “There are characteristics of face-to-face human interactions, particularly the space-time contexts in which such interactions take place, that the emerging technologies are either pragmatically or logically incapable of replicating”. It is also apparent that face-to-face meetings have a lot of side discussions, story telling and interjections which are hard to deliver online (Olson and Olson, 2000).

Other researchers focus their discussion on non-verbal (text-based) versus verbal communication. For example, Leh (2001, as cited by Svensson, 2002) suggests that the available research can be classified into two categories: one that supports that verbal communication is the richest type of communication, and one that proposes that technology artefacts can compensate for the lack of verbal cues (Cummings et al., 2002; Svensson, 2002; Utz, 2000). It is commonly acknowledged that non-verbal social information is implicitly transmitted amongst participants in face-to-face communication. During face-to-face conversations people rely on multiple modes of communication such as voice tone, volume and pace, eye movement and eye gaze, inflection/nuances, facial expressions, hand gestures and body language (Warkentin et al., 1997). These cues provide for a methodical conversation process. They serve to facilitate turn taking, convey subtle meanings, provide feedback, and acknowledge mutual understanding. In other words they regulate the overall conversation flow. Nevertheless, a multitude of appealing and engaging mechanisms exist to compensate for that in computer-mediated interactions, for example following a structured dialogue format. This results in a type of communication that has been repeatedly proven as beneficial for virtual communication (Gunawardena, 1995 as cited by Svensson, 2002; Utz, 2000).

There is also a debate on whether collaborative technologies enable better face-to-face meetings. There is evidence that as soon as team members have a number of in-person meetings, collaborative technologies can be used to support the ongoing virtual collaboration between members. Dispersed group members can draw upon collaborative technologies for continuous development of relationships, achievement of common goals, and creation of communities of interest (Qureshi and Zigurs, 2001). A significant body of research related to virtual teams (Furst et al., 1999; Olson and Olson, 2000) suggest the need for at least one early face-to-face meeting of virtual team members to establish team consensus and initiate the development of team norms. Kreijns and Kirschner (2001) focus on the role of the IT-based artefacts in this context. They point out that computer-mediated social interaction should not be presumed simply because of the presence of the technology. In other words, they suggest that we should not take the social interaction for granted when we communicate via electronic means. They also argue that, in order to engage people to

lively participate in virtual collaboration, IT systems should support social affordances, group awareness, and group cohesiveness (Kreijns and Kirschner, 2001).

Existing research indicates that team members' satisfaction of completing a task in a virtual environment may depend upon the type of communication technology used. Some researchers suggest that "the richness of communication technology media may reduce many of the problems associated with virtual team interaction" (Furst et al., 1999, p.252) and that "if more flexible tools for problem-solving and decision-making are made available, the collaborative technology could be adapted to a greater extent" (Qureshi and Vogel, 2001, p.9). Others yet suggest that "successful virtualisation does not depend on the degree of technological sophistication. It's how the tools are used that matters" (Qureshi and Zigurs, 2001, p.85). Regardless of this conflict, and whether focus should be on the available technology or on how it is used, organisations wishing to embrace successful virtual collaboration are challenged to find 'win-win' situations. Discovering what can make virtual collaboration as effective as co-located collaboration is not a straightforward task however. This suggests that further research is needed in order to identify viable solutions.

Following the above discussion, it can be observed that the centre of attention in the available literature is on which form of communication outperforms the other. However, the attention should not be whether we should have strictly face-to-face or strictly distant communication or even whether we should choose between verbal or text-based interaction. The question should be how we can merge the above approaches to create a truly efficient collaborative setting regardless of members being dispersed, co-located or a combination of the two.

It is also crucial to realise that the arguments used against computer-mediated communication, such as lack of trust, cultural differences and language, may also hinder co-located teams. Co-located groups of people who share the same culture and background, who know each other for a long time, and have worked together in manifold projects can still face situations which involve conflicts, lack of trust and motivation. Situations like these are somehow embedded in human nature, so they are inherently built into virtual interactions. Hence we should not focus on the aspects that technology cannot entirely support. Instead, we should identify the beneficial

elements of face-to-face interactions and find innovative ways to provide support for them in virtual settings. This will be the first step towards the next generation of collaborative technologies. The subsequent step will be to improve the adaptability and acceptability of the technology and motivate people to use it. We will discuss the use of open-source software in this context.

Even though the commercialization of software by firms provided various user benefits at the same time it has limited the opportunities for software manipulation. The key feature of open-source software is the fact that it enables users with special requirements to modify and enhance programs in order to meet their needs (Yamauchi et al, 2000). This creates a focus on the elements which the technology can achieve, not the ones it cannot possibly implement. These include flexibility, time and space restrictions, collaboration using IT artefacts, etc. It is also important to note that as people become progressively more experienced and comfortable with using technology these possibilities are becoming more appealing. Especially since people learn to use the technology from a young age, its use becomes more and more ubiquitous hence requiring less effort to use it.

Finally, as the borderline between strictly computer-based and strictly face-to-face collaboration starts to fade, organisations increasingly seek for novel, innovating opportunities. As a result, a combination of co-located and dispersed communication starts to take place in most workplace and educational settings (Qureshi and Vogel, 2001). A balance between reality and virtuality seems to be the most apparent settlement. Such a hybrid context provides the ideal social milieu for studying the different dimensions of collaboration. Unquestionably, virtual environments raise a number of issues but what really matters is how to harvest the benefits of the technology, minimise its limitations and finally, improve team work and collaboration. The purpose of the following sections is to synthesise the available literature in order to identify the key characteristics of virtual collaboration and provide suggestions for dealing with the existing challenges.

## **2.1. Advantages of virtual collaboration**

Probably the most profound benefit for virtual collaboration is flexibility (Qureshi and Zigurs, 2001). With organisations that exist only as virtual entities, communicating solely through collaborative technologies offers vast flexibility to employees and clients alike. Through collaborative technologies people can conduct their work on the move, from their clients' office, from their homes. Most importantly, they can do this at any time of the day hence harvesting the opportunity for global collaboration (Smith, 2000). Rather than a physical office, virtual organisations provide employees with a laptop, a mobile phone, and an internet connection to communicate with each other and with clients. These new ways of working are increasingly being adopted in organisations (Riedmann et al. 2006; Wyncarczyk, 2005). Successful technologies combine simplicity with adaptability to enable more dynamic virtual collaboration (Qureshi and Zigurs, 2001). In educational settings too, flexibility is evident. Through interactive online workshops and virtual classrooms learning can be much easier, more interesting and instructive, and motivate students to learn from each other by taking part in collaborative projects (Alavi and Leidner, 2001; Wasson and Morch, 2000; Santoro et al., 1999; McConnell, 2000).

Diminishing distance and time barriers and offering flexibility are only some of the benefits of collaborative technologies. Virtual collaboration presents opportunities for sharing knowledge, for mobilizing distributed resources toward joint efforts, and for providing more innovating and personalised products and services (Qureshi and Zigurs, 2001; Smith, 2000). Furthermore, the opportunity to manage knowledge and making it applicable on new projects is a key characteristic of collaborative technologies. A challenge facing modern organisations is identifying and capitalizing on their core competencies. Core competencies are usually dispersed in multiple parts of the organisation, exist in the minds of different employees, and pioneer through conversation and interaction. Collaborative technologies enable the organisation's core competencies to be maximised by supporting knowledge management (Qureshi and Zigurs, 2001). For example, virtual conversations about how to deal with a particular product defect can be archived in the organisation's knowledge repository hence becoming part of the organisational memory to be referenced in the future when other employees confront similar problems (Qureshi and Zigurs, 2001, p.87-88;

Furst et al., 1999, p.253). Qureshi and Zigurs (2001, p.88) suggest that when used in this way virtual collaboration “enables the creation and maintenance of knowledge networks through which people in different parts of the organisation cooperate and consult with each other to provide knowledge-intensive services”.

Furst et al. (1999, p.253) also assert that: “As knowledge management becomes increasingly important for gaining a competitive advantage, the effective use of virtual teams may become a prerequisite for organisations to compete successfully”. Thus the fact that virtual collaboration allows organisations to compete effectively can be considered as an additional benefit. The firm’s ability to create and disseminate knowledge in a timely and effective way can provide this competitive advantage. Especially in a rapidly changing organisational environment, which requires innovation and fast responsiveness to change, knowledge management is the key to sustaining a competitive presence in the marketplace (Furst et al., 1999).

Contemporary competitive demands have forced many organisations to increase the levels of flexibility and adaptability in their operations. A growing number of these organisations are exploring the virtual environment as one means of achieving increased responsiveness to client needs (Furst et al., 1999). Within these virtual environments companies can conduct international business and reach clients globally as easily as never before. Qureshi and Zigurs (2001, p. 86) emphasise that “Collaborative technologies deliver fast responses to clients and enable the right mix of people and knowledge matched to specific client problems”. New technologies allow virtual teams to work better, faster, cheaper, and smarter, which consecutively helps organisations to improve efficiency and productivity, acquire expert knowledge from internal and external sources, and transfer best practices instantaneously (Furst et al., 1999; Huber, 1990).

Moreover, virtual collaboration allows people to constantly learn from each other and develop their critical thinking (Alavi, Wheeler, and Valacich, 1995). The learning process is inherent in any form of group work, being face-to-face or virtual, work-related or educational. Many studies argue that virtual interactions may provide additional benefits compared to traditional, face-to-face ones. Firstly, virtual teams enable people to expand their social networks both within and between organisations.

Secondly, the work methods of virtual teams can become an important part of the organisation's knowledge repositories or its 'organisational memory' as mentioned above (Qureshi and Zigurs, 2001; Furst et al., 1999; Smith, 2000).

Another advantage involves the cross-functional coordination of activities. When members with various skills and perspectives are engaged in group work for producing a collective output or product, this coordination is crucial. Coordination of group activities and group members is easier through technology by keeping logs of previous meetings, various versions of documents, and tracking the contribution of different members (Smith, 2000). Nevertheless, cultural differences and team heterogeneity may hinder communication and make group coordination a challenge for virtual teams, as we will discuss in the next section.

Finally, issues of time and space are generally of less concern in the virtual environment. In fact, the reason why many organisations use virtual teams is to speed up the development processes or the response to customers' needs. In addition the increased costs associated with maintaining office spaces and the increasing travel expenses make the effective use of virtual teams an attractive option (Lipnack and Stamps, 1997 as cited by Furst et al., 1999).

### **2.3. Challenges of virtual collaboration**

Along with the above benefits, virtual collaboration faces many challenges. Virtual teams are challenged essentially because they are inherently implicit; they exist through ICT rather than being face-to-face. Virtual teams are expected to effectively collaborate and produce results, successfully negotiate cultural differences, and most importantly they are expected to accomplish all the above through computer-mediated communication. One of the reasons these teams fail is because they overlook the implications of the obvious differences between virtual and physical environments. People do not make accommodation for how different it actually is when they and their co-workers no longer work face-to-face (Lipnack and Stamps, 2000, as cited by Smith, 2000). Lipnack and Stamps (2000, p.19, as cited by Smith, 2000) assert that "Teams fail when they do not adjust to this new reality by closing the virtual gap".

Another reason might be that the giant steps in Information Technology in the turn of the century may have unleashed unreachable goals (Olson and Olson, 2000).

Social interaction is a challenge facing virtual collaboration which has attracted vast attention in the literature. Some researchers argue that it is hard to maintain rich communication due to the lack of non-verbal cues, the inability to take advantage of incidental meetings and discussions, and the insufficient support of socio-emotional issues. As Furst et al. (1999, p.252) point out: “Just as it is difficult to pat team members on the back after a virtual success, it may be even more difficult to throw a sympathetic arm around a virtual team member’s shoulder after a virtual team failure”. There is also the case where members find it hard to engage in spontaneous written communication which makes social interaction even more distant (Hron et al., 2000; Jarvenpaa and Leidner, 1999; Warkentin et al., 1997; Smith, 2000).

Olson and Olson (2000) have extensively reviewed synchronous collaborations within co-located and dispersed groups focusing on the socio-technical conditions required for effective distance work. It was found that groups with high common ground and loosely coupled work, with eagerness to collaborate and use collaborative technologies have a better chance at succeeding with remote work. However, derivations from any of these factors create a strain on the relationships between group members and the quality of group work. More effort will hence be required to adjust work and successfully collaborate under these circumstances.

Establishing common ground is the first step for successful collaboration, despite being co-located or virtual. It involves managing conflicts, unclear expectations, and lack of mutual understanding (Egea and Gregor, 2002; Robey et al., 2000; Smith, 2000). Misunderstandings occur regularly and managing them has proved to be a very intimidating process. Given the text-based demands of many distant communication systems, skills required to diagnose conflicts and solve communication problems are difficult to enforce in virtual teams (Hron et al., 2000; Jarvenpaa and Leidner, 1999; Warkentin et al., 1997; Smith, 2000). These challenges are often linked to lack of motivation for collaboration (Olson and Olson, 2000).

The media choices are often constrained by social and organisational factors (Olson and Olson, 2000). On one hand, employees often fail to realise the potential of new technologies and tools. On the other hand, employers do not provide the right incentives to motivate them use the technology, which ultimately curtails their performance and productivity. Lack of motivation is considered as one of the major and most complicated sources of groupware failure because not only its effects can be catastrophic in terms of team performance, but also managers cannot easily recognize what the problem originally was (Orlikowski, 1992). When people are not willing to use the groupware, or do not get the appropriate training, then the groupware is most likely to be set aside or be completely rejected with people finding alternative ways to conduct their work (Vandenbosch and Ginzberg, 1996). The lack of training is only one of the reasons which may lead to lack of motivation. The nature of the work may also have an effect on the acceptance or rejection of the technology. When people's work depends on large data files or dispersed resources, they are more eager to collaborate using the technology. On the contrary, when people fear of losing control over their data or missing a key discovery, for which someone else will get credit, they are less interested in adopting the technology (Olson and Olson, 2000).

Another issue that received a great deal of attention in the literature is establishment of trust within virtual teams (Furst et al., 1999; Qureshi and Vogel, 2001; Jarvenpaa and Leidner, 1999; Robey et al., 2000; Smith, 2000). Factors such as time, distance, cultural diversity and global distribution of members, and the reliance on technology may negatively influence trust in virtual teams (Jarvenpaa and Leidner, 1999; Olson and Olson, 2000).

From the afore-mentioned factors, cultural diversity in particular is seen as a major challenge in many organisations. An example of virtual collaboration between European and Latin American team members revealed instances of misunderstanding due to cultural differences in perception. It was reported that these differences occasionally impeded communication between the team members ((Qureshi and Zigurs, 2001), p.86).

In addition, financial resources play a significant role in virtual settings. The value for money factor is a critical challenge for organisations. Even though technology

becomes increasingly more powerful, affording the most up-to-date systems is not always a feasible option for individuals or even organisations. The purchase of reliable technologies influences team effectiveness and member satisfaction with the team process (Huber, 1990; Bettenhausen, 1991 as cited by Furst et al., 1999). Without sufficient financial resources, appropriate technologies may not be available. The high cost of advanced IT may limit an organisation's ability to successfully link dispersed members. In addition, team members may not have access to the same ICTs. This may lead to a compatibility gap between them which can impact the quality of the collaboration and constrain team performance.

Other weaknesses of conducting virtual collaboration include technical difficulties and technology limitations such as software failures, restricted bandwidth, delays, and slow access times (Egea and Gregor, 2002; Robey et al., 2000; Smith, 2000). These limitations constitute the most common factor that hinders effective virtual interaction due to frustration caused by long response times. In addition, dispersed members often have to adapt their work patterns to location and technology constraints. Despite the advances in mobile communications and networks, people still complain about the quality of communication over audio and video conferencing. Figuring out who is speaking, or what someone is referring to or pointing at, adjusting the volume and focusing the camera to the speaker are some of the most common practical problems of distant communication. These problems result mostly due to the lack of training on using the equipment or the technology not being upgraded (Olson and Olson, 2000). Even with the best technologies at hand, if the team members are not adequately trained how to use it, then team performance and productivity will significantly suffer (Furst et al., 1999). In cases like these, people try to find ways to compensate by adapting new behaviours such as identifying themselves before speaking, following turn-taking protocols, moving closer to the microphone when others complain about the sound, etc. Although this adaptation procedure usually makes effective communication in dispersed teams possible, it requires higher effort from the participants compared to face-to-face communication (Olson and Olson, 2000). Therefore, organisations should consider additional aspects beyond the availability of the technology. For example they should ensure that not only they provide the right equipment but also that people are properly trained and are willing to use it. Prompting technology use is not always straightforward however.

Coordination of people and activities has similarly appeared to be challenging, especially in cases where the tasks at hand are tightly coupled. When group work involves highly interdependent tasks, it is hard to be conducted remotely. Collaborative technologies do not provide as rich awareness as face-to-face interactions, neither do they support rapid repair of uncertainty, at least not until now. In situations like these participants tend to reorganise work so that tightly coupled work is assigned to co-located members. A situation observed in many cases is that people reorganise their work in such a way so that they do not have to rely on tight collaboration with remote team members. In other words, the work is re-adjusted to fit the situation instead of the technology being adjusted to fit the work at hand (Olson and Olson, 2000). This is because most collaborative technologies cannot effectively support tight interactions. Even worse, different work activities require different styles and varied frequency of interaction between group members (Olson and Olson, 2000).

Maintaining high team performance is also demanding in virtual settings. One factor that can affect performance is the group dynamics or group synergy (Furst et al., 1999). In order to excel, both communication and technical skills are required due to the demanding, task-specific character of many group tasks. In addition, absence of efficient group leadership may lead to social loafing, free-riding, groupthink and group shifts (Olson and Olson, 2000), which will in turn hinder team performance. Such negative behaviours are particularly common in virtual teams and they can diminish the overall group effectiveness. Olson and Olson (2000, p.152) suggest that “Remote work is hard to conduct, even with the best of today’s technologies”. Managing human resources and coordinating work in virtual settings is not straightforward since it requires an orchestration of many influential aspects.

Finally, the biggest challenge that can bring an organisation against multifaceted difficulties is probably the fact that when something goes wrong, regulating the correlated negative effects can be very complicated, and can cost a big amount of time and money. This implies the importance of finding efficient ways of preventing these challenges of happening in the first place.

## **2.4. Techniques for overcoming the challenges**

In order to overcome some of the challenges engaged in virtual collaboration, researchers have suggested a number of guidelines and rules (Furst et al., 1999; Qureshi and Zigurs, 2001; Egea and Gregor, 2002; (Jarvenpaa and Leidner, 1999). In general, for virtual groups to perform effectively organisations must provide the right context including appropriate financial, technical, and social support. It is also important to address these factors in conjunction to one another; failure to consider the linked effects will lead to a “virtual disaster” (Furst et al., 1999, p.255).

Virtual communication is often criticised for its failure to support social interaction, compared to face-to-face communication. One way to envision the possibilities of future collaborative technologies is to explore how the characteristics of face-to-face interactions can be supported in virtual settings (Olson and Olson, 2000). Genuine examples of technology that achieve this today include video conferencing, video recording, and augmented reality. Such technologies have already leveraged the way people communicate and with the increasing availability of faster computer networks and computer graphics, they hold many more opportunities for advancement.

In addition, it is widely acknowledged that virtual collaboration offers possibilities far “beyond being there” (Hollan and Stornetta, 1992). Hence, another way to improve future collaborative technologies is to identify the distinctive qualities of both face-to-face and virtual interactions, and explore how we can best combine them (Olson and Olson, 2000). Greater support for facial expressions, verbal and non-verbal cues, and body gesturers will empower interaction and make the establishment of trust and common ground easier. In other words, by making the virtual environment feel more natural, we can have the best of both worlds. This will be a step towards the ultimate goal, which is to make group members perform equally well, despite being co-located, dispersed, or remote.

Effective communication also requires that the participants share the same knowledge and that they are aware they share it. In an attempt to establish common ground people make assumptions based on general knowledge on people’s background, appearance, and behaviour during their interaction. This is an on-going and

collaborative process through which participants progressively establish mutual understanding so that the conversation or group work can proceed (Olson and Olson, 2000, p.157). Common ground is usually established using cues and rapid back and forth questions. The fewer the available cues, the harder it is to construct common ground, and the more likely it is for misinterpretations to occur. Researchers suggest that common ground is harder to establish in virtual environments precisely because of the lack of these cues. In contrast, when teams are co-located it is relatively easier to establish common ground because people are more familiar with each other, they share the same local context, and also because they are aware of who is responsible for what, and what remains to be done. The more common ground people establish, the more effective the communication and the greater the performance, even over poor media. Olson and Olson (2000, p.161) suggest that if participants find it hard to establish common ground, they should travel and get to know each other face-to-face, or use the highest bandwidth and the best groupware available. This is where video connections can really make a difference in virtual teams, especially when travelling is not an option. Huber (1990) suggests that simple electronic communication, such as e-mails or bulletin boards, can be used to exchange factual or technical information. However, in order to communicate more complex or socio-emotional information, more advanced technologies, such as video conferencing, may be required. Video communications are essential for establishing common ground when people are dispersed, come from different cultures, or are not familiar with each others' background.

Amongst the virtual teams Olson and Olson observed (2000), it was found that those using a video channel performed significantly better than those using only audio or text-based interactions. Gestures and facial expressions can be communicated, and artefacts can be shared to clarify discussions and illustrate ideas easier. Moreover, participants can understand what the speaker says by watching him speak, and at the same time the speaker can see if the recipients actually understand the point he is trying to make. This shows again that video technologies play an important role in distance work and virtual collaboration and they are expected to play even greater role in the future collaborative technologies (Olson and Olson, 2000).

Establishment of common ground is highly related to establishment of trust. Trust is essential for bridging the geographically dispersed members and determines the performance of the virtual team (Furst et al., 1999). Therefore, there is a genuine need to adopt effective strategies for establishing trust within virtual teams. Firstly, teams should meet face-to-face when possible, or at least once at the outset of the group project. Secondly, members should agree on individual roles, set clear responsibilities, and ensure they have mutual end-goals. Thirdly, awareness and familiarity with the state of the interaction makes communication easier. Finally, ensuring team members have established a common ground based on trust and mutual understanding, as early in the process as possible, can minimise potential negative effects (Robey et al., 2000; Olson and Olson, 2000).

Heterogeneity is also likely to be high in virtual teams since team members are likely to represent different skills, backgrounds, experiences, cultures, locations and functions. As virtual teams become more heterogeneous due to more complex and varied team tasks, successful management of team cooperation becomes increasingly important. Heterogeneity can either facilitate or hinder virtual collaboration, but effective mechanisms do exist for moderating this, such as setting clear responsibilities and following structured task processes (Furst et al., 1999). Most importantly, diversity in culture, skills or expertise should not be considered as a barrier for virtual collaboration but as an opportunity to combine ideas and innovate. People with different backgrounds are likely to have different skills and therefore they are invaluable for successful outcomes. Hence organisations are prompted to take full advantage of diversity in virtual collaboration (Qureshi and Zigurs, 2001).

Successful collaboration is built on the assumption that co-workers need to exchange information and knowledge and that they are rewarded for doing so. Managers should create a collaborative spirit within the team before introducing new groupware and collaborative technologies. They should encourage people to collaborate by offering the right incentives, as well as provide adequate training focusing on the core functionalities (Olson and Olson, 2000)) Incentives make participants more or less willing to share information, collaborate, and use collaborative technologies. Olson and Olson (2000, p. 164) present many examples where the lack of motivation led to limited use of the available collaborative technologies. People claim they would learn

how to collaborate using the tool if they were paid overtime, or if they would be given a bonus or a day-off. Also, in many cases companies do not provide the required training for how to use the tool, and fail to explain its key functionalities and how it could make people's work easier. This lack of incentives is crucial and it can make the difference between acceptance and rejection of the technology.

There is also a need to promote a broader corporate culture that encourages and supports collaborative virtual activities. 'Presenteeism' is traditionally seen as evidence of commitment to the organisation. Promoting a corporate culture where 'absenteeism' is appreciated is essential for successful virtual communication. It can also be considered as an incentive for using the technology (Furst et al., 1999).

Regarding the need to resolve work coordination, assist problem solving and manage conflict within virtual groups, Hron et al. (2000) investigated the use of dialogue structuring to keep online conversations coherent. Dialogue structuring involves tools that facilitate mutual explanations and coordination during the problem-solving phase of teamwork. They concluded that when a dialogue structure was followed, either implicitly or explicitly, it led to more coherent discussions, easier coordination of activities, and mutual knowledge construction. In general, following a structured communication approach and explicitly establishing informal rules of how work needs to get done within virtual teams, can facilitate virtual interaction (Furst et al., 1999). Paradoxically, the structured approach of many collaborative technologies and their task-focused design create an environment where people can deal with cultural differences, overcome diverse perceptions, and focus on common goals (Qureshi and Zigurs, 2001). However, researchers caution that restrictive means of structuring could possibly hinder collaboration (Hron et al., 2000).

The ability to instigate commitment is an important first step towards effective team performance. In the absence of face-to-face contact, virtual team members must rely on their collective understanding and commitment to team goals to guide their behaviours. Furst et al. (1999) suggest that mechanisms for creating team identities include on-line training and team building. Qureshi and Zigurs (2001, p.86) also describe how training team members in trust building, communication etiquette, agenda sharing, and timely response is seen as essential for accomplishing efficient

ongoing virtual collaboration. In virtual teams, not only the joint task but also the team itself emerges through the technology. Hence, training on team development processes is crucial (Furst et al., 1999).

Furthermore, IT support is critical for dispersed members; virtual collaboration simply cannot exist in the absence of technology. Making sure everybody knows where to access shared data, and how, is essential for increasing team performance. Case studies have shown that computer-mediated groups are more appropriate for brainstorming types of activities but less effective for actual problem solving. The same studies have also shown that given the appropriate technology, virtual decision making can also be effective (Furst et al., 1999). These conflicting results highlight the importance of finding the right technology-task fit. Other performance dimensions such as knowledge management, creative use of communications technology and consensus building are also critical in order to encourage both confidence and competence in virtual group activities (Furst et al., 1999).

In addition, the enforcement of norms in terms of group members' interaction can empower team performance. For instance, promoting new ideas, encouraging member involvement, and rewarding successful ventures will increase group effectiveness (Furst et al., 1999). Even more, setting clear responsibilities, following well-defined work processes and successfully managing the group can minimise social loafing, free-riding, groupthink and group shifts while at the same time maximise member involvement and group productivity.

Until now, people have been adapting their work patterns on the technology available to them. In other words, the work is readjusted to fit the situation instead of the technology being adjusted to fit the work at hand. The true necessity however is to allow people to adjust the technology according to their work and collaboration patterns which will inevitably increase their motivation to use it (Olson and Olson, 2000). This can be accomplished in two steps. Firstly, it is imperative that group leaders should consider which tasks could successfully be executed by remote members before they assign them the work. If the tasks appear to be tightly coupled, they should consider alternative ways, such as requesting members to participate face-to-face, at least as long as they establish common ground. Work conducted by remote

members has to be loosely-coupled, straightforward and unambiguous in order to succeed. Secondly, they should choose the most appropriate technologies for the tasks at hand.

For virtual collaboration to excel, the right set of technologies and infrastructures need to be present. However, the availability of the right tools at the right place and in the right time is not all it takes for virtual collaboration to succeed. The right attitude toward the technology is also essential. When people do not take the time to save their experiences in the organisation's knowledge repository for others to access it in the future, when they are never online, when they do not follow the communication protocols, and so on, the rejection of the technology will be fatal. Similarly, when organisations attempt to introduce a technology which is more advanced than the one currently used, it will result in making participants feel disoriented and daunted, which again will lead in failure of the technology. New technologies often require new work patterns. Since people are not likely to change the way they work very rapidly, advancements in technology should not either. Advanced technologies should be introduced gradually and, when in place, they should deliver the expected functionality to avoid frustration and false expectations of the users (Olson and Olson, 2000).

Organisations and group members should make the best of the available technologies. Some guidelines for increasing the technology's value for money are given next. First of all, sharing of personalised knowledge should be encouraged since it can enrich the available information at the organisation's knowledge repositories. In addition, group members should learn how to form networks of expertise, so that they learn from each other while collaborating. Finally, they should be able to accumulate new skills quickly and use the available technology for gaining a competitive edge.

As far as the technology is concerned, better design and more powerful infrastructures will solve a number of the limitations of current groupware that support distance communication and collaboration. The ever-increasing upgrading of the Internet and the wide spread of Virtual Private Networks (VPNs) and intranets hold many possibilities. Along with the emergence of enabling technologies, they are expected to close the compatibility gap and downsize the limitations from which technology

suffers today. Supplementary actions such as acquiring the highest possible bandwidth depending on the number of users and the task at hand, purchasing user-friendly groupware with adaptable functionalities, and offering continuous software maintenance and technical support can really reduce the frustration from technology failures. “It is well known that any delay greater than 500 msec will severely disrupt conversational flow” (Olson and Olson, 2000). Greater bandwidth will solve the disruptive influence of today’s delays in audio and video transmissions. It will also allow for larger, high resolution life-size displays of remote workers, making their interaction experience more immediate, friendly, and pleasant. Besides that, organisations should ensure people use the latest versions of the software and that they all use the same version to avoid incompatibilities. Also, team members should agree in advance on which technologies and software versions will be used in the venture and ensure all members have access to the same set of Information and Communication Technologies (ICTs). Finally, they should ensure they are all properly trained on how to use them and that they are familiar with the key functionalities.

Despite technology limitations (e.g. poor support for eye contact across the video link or low resolution), and in spite of the amount of effort needed to compensate for them, after a long time of using the technology these appear to fade into the background. Given that the groupware has useful functionality participants will eventually develop new practices to adjust it to their work patterns. Experience with technology will help people find innovating ways to successfully adjust the technology to their work (Dourish et al., 1996).

Furthermore, current efforts in the area of virtual reality are expected to yield high quality virtual meeting rooms that provide a higher support for eye-contact, common referent and deictic options. Such advances suggest that by carefully considering more humanistic factors in the design of collaborative technologies, many technical ways for enhancing electronic communications will evolve, bringing us closer to face-to-face communication. Perhaps even more appealing is the prospect that future tools and technologies may provide capabilities that are in some ways superior to face-to-face interaction (Hollan and Stornetta, 1992).

Today's tools and technologies have many useful features; nonetheless, future collaborative technologies are expected to better support the benefits of co-located interaction in virtual settings (Olson and Olson, 2000). Even though some key facets of co-located interactivity, such as the presenteeism and spatiality of an individual will be very resistant to technological support advances in virtual and augmented reality certainly look promising.

Researchers contend that there is an increasing trend towards virtual collaboration practices (Egea and Gregor, 2002; Hines et al., 1998; Robey et al., 2000; Rugelj, 2000; Yaverbaum and Oacker, 1998). However, in order these practices to be successful, they must consider the potential challenges collectively and in turn identify the most relevant mechanisms for addressing them. The following table summarizes the challenges faced by virtual teams and the suggested ways for addressing them.

<b>Social interaction challenges</b>
<ul style="list-style-type: none"> <li>▪ Support the characteristics of face-to-face interactions in virtual settings.</li> <li>▪ Combine the benefits of face-to-face and virtual communication.</li> <li>▪ Adopt improved technologies in situated settings.</li> <li>▪ Support facial expressions, verbal and non-verbal cues, and body gesturers in virtual settings.</li> </ul>
<b>Establishment of common ground, managing conflicts, unclear expectations, and lack of mutual understanding</b>
<ul style="list-style-type: none"> <li>▪ Ensure that members share the same knowledge and set clear responsibilities and tasks.</li> <li>▪ Use video communications to allow cues to be easily communicated.</li> <li>▪ Have at least one face-to-face meeting.</li> <li>▪ Acquire the best groupware and use the highest bandwidth.</li> <li>▪ Use dialogue structuring, follow a structured communication approach.</li> <li>▪ Establish rules of how work needs to get done.</li> <li>▪ Successful management of team coordination and cooperation.</li> </ul>
<b>Lack of motivation to collaborate</b>
<ul style="list-style-type: none"> <li>▪ Provide incentives (day-offs, bonuses, etc)</li> <li>▪ Provide appropriate training.</li> <li>▪ Explain the key functionalities of the tool.</li> <li>▪ Create a collaborative spirit within the team.</li> <li>▪ Promote a corporate culture that encourages and supports collaborative virtual activities.</li> </ul>
<b>Establishment of trust</b>
<ul style="list-style-type: none"> <li>▪ Meet face-to-face when possible or at least once at the beginning.</li> <li>▪ Support facial expressions, body gestures, verbal and non-verbal cues in virtual settings.</li> <li>▪ Agree on individual roles and set clear responsibilities.</li> <li>▪ Ensure members share the same end-goals.</li> <li>▪ Establish common ground as early as possible.</li> </ul>
<b>Tightly-coupled work</b>
<ul style="list-style-type: none"> <li>▪ Group leaders should consider which tasks could successfully be executed by remote members.</li> </ul>
<b>Cultural differences, group synergy</b>

<ul style="list-style-type: none"> <li>▪ Successful management of team cooperation.</li> <li>▪ Take advantage of diversity.</li> <li>▪ Set clear responsibilities and follow structured task processes.</li> </ul>
<b>Financial resources, value for money</b>
<ul style="list-style-type: none"> <li>▪ Make the best of the available technology and use it for gaining a competitive edge.</li> <li>▪ Encourage knowledge sharing.</li> <li>▪ Increase the availability of and accessibility to information.</li> <li>▪ Form networks of expertise.</li> </ul>
<b>Technology limitations, compatibility issues</b>
<ul style="list-style-type: none"> <li>▪ Acquire high bandwidth depending on the number of users and the task at hand.</li> <li>▪ Purchase user-friendly groupware with adaptable functionalities.</li> <li>▪ Offer continuous software maintenance and technical support.</li> <li>▪ Upgrade to the latest versions of software.</li> <li>▪ Ensure everyone uses the same version of the software.</li> <li>▪ Agree on the software and ICTs to be used in advance.</li> </ul>
<b>Technology readiness, motivation to use the technology</b>
<ul style="list-style-type: none"> <li>▪ Make technology easily adjustable to different work patterns.</li> <li>▪ Establish common ground.</li> <li>▪ Assign loosely-coupled, straightforward and unambiguous tasks to dispersed members.</li> <li>▪ Choose the most appropriate technologies for the tasks at hand.</li> <li>▪ Make the right technologies available at the right time and place.</li> <li>▪ Promote the right attitude towards using the technology.</li> <li>▪ Provide incentives and appropriate training.</li> </ul>
<b>Coordination, problem-solving</b>
<ul style="list-style-type: none"> <li>▪ Follow a structured communication approach.</li> <li>▪ Establish informal rules of how work needs to get done.</li> </ul>
<b>Maintaining high team performance, lack of training</b>
<ul style="list-style-type: none"> <li>▪ Instigate commitment and build consensus within the team.</li> <li>▪ Train team members to effectively use the technology.</li> <li>▪ Train members in team and trust building, communication etiquette, agenda sharing, and timely response.</li> <li>▪ Ensure everybody knows where and how to access shared data.</li> <li>▪ Provide the appropriate technology equipment and IT support.</li> <li>▪ Find the right technology-task fit.</li> <li>▪ Efficient knowledge management.</li> <li>▪ Enforce of norms in terms of group interaction.</li> <li>▪ Encourage new ideas and reward successful ventures.</li> <li>▪ Set clear responsibilities and follow well-defined work processes.</li> <li>▪ Encourage competence in virtual group activities.</li> </ul>

*Table 1: The challenges faced by virtual teams*

### 3. OPEN-SOURCE SOFTWARE AS A VIABLE TOOL FOR VIRTUAL COLLABORATION

Free and open source software is a revolutionary form of software development. It presents a challenge to propriety software in that it is reliable, stable and is continuously improvised. Particular open source developments such as the Linux operating system and Apache Web Server have proved to be serious competition to commercial products that have dominated the marketplace (Kim, 2003). The ideology behind the open source movement is to make the source code (series of instructions

written by software programmers that makes the software application functional) available to all for use, modification and reuse (OSI, nd).

The open source community is largely virtual and loosely knit, comprising of developers and end users who work and interact via web based computing environments such as email, electronic bulletin boards, internet rely chats(IRC) and websites or sharing open source artefacts (Scacchi, 2002).

Although there is no formal organizational structure for the open source communities most members assume certain role by themselves depending on their interest in particular projects. The roles are could be that of project leader, core member, active developer, peripheral developer, bug fixer, bug reporter and passive user (Xu and Madey, 2004).

The OSS community promotes the development of free software that can be copied, modified and redistributed for free (Stallman, 1999). As a result of such a form of open source development the community has seen numerous benefits such as software validity, high software collaboration, fewer defects and lower software acquisition costs (Koch and Schneider, 2000). Further, beliefs and values associated with the free software movement (Stallman, 1999) become a valuable asset for CMC and facilitate teamwork, resolve conflicts and help building the virtual teams (Elliott and Scacchi, 2004). This has not been addressed by traditional CSCW literature.

Prior CSCW research has not addressed how the aspects of OSS such as collection of IRC messaging and logs, email lists, and periodic digests can be collectively mobilized and routinely used to create a virtual organization that embodies, transmits, and reaffirms the cultural beliefs, values, and norms that create virtual identities and increase trust, such as those found in free software projects ((Elliott and Scacchi, 2004).

Very few researchers have addressed how collaborative systems can be constructed using OSS and how they overcome some of the persistent problems of the existing collaborative systems. Steinfield et al. (1999) have developed a collaborative system

called TeamSCOPE that focused on improving the awareness of activities amongst virtual groups, enhanced communication and exportation of resources. TeamSCOPE has an open source architecture that allows easy modification of different parts of the collaborative system. However they do acknowledge that such an open source system needs further development. This suggests that although there is some interest in the development of open source platforms to support CSCW, it is still in infancy and requires extended research.

#### **4. DISCUSSION**

The use of virtual teams appears to be on the increase. Yet, at the same time, there is a sheer volume of criticism that the increased use of virtual teams has not been accompanied by concomitant research efforts to better understand the social-psychological contributors to effective virtual collaboration (Furst et al., 1999, Smith, 2000). Many researchers form research communities challenging each other's claims and suggestions but fail to provide comprehensive empirical information and methodological models and theories themselves. Although some comprehensive case studies examine the effectiveness of virtual teams more comprehensive theory development is needed.

Furthermore, some of the existing literature appears to be mainly descriptive. Recent research also lacks striking empirical data that explore the dynamics in the virtual work environment with most studies 're-inventing the wheel'. Computer-mediated collaboration has the potential of becoming more adaptable. This involves challenges for organisations as well as designers of CSCW systems.

With collaboration initiatives becoming more mixed-mode, with blended and blurred borders, it seems increasingly less relevant to use the dichotomy of distance vs. co-located endeavours. The focus should be on how collaborative technologies can improve the ways people work together and how they can motivate a collaborative behaviour. The complex nature of virtual collaboration involves a range of implications that remain to be studied and understood. The vague assumption that previous theory and practice on traditional group processes and outcomes can be easily generalised to the virtual environment needs more rigorous and thorough

investigation. There has been however sufficient time and experience from which can build strong foundations for further research.

This paper explores how collaboration is established in face-to-face as well as virtual environments. It identifies the benefits and challenges of distant collaboration and synthesizes the solutions discussed by scholars in the stream of CSCW. Through the exploration of current debates on virtual collaboration, this paper also emphasises the research areas where further investigation is needed and discusses the potential of open-source software in the context of virtual collaboration.

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