GLOBAL TEAMS: FUTURISTIC MODELS OF COLLABORATIVE WORK FOR TODAY’S SOFTWARE DEVELOPMENT INDUSTRY

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ABSTRACT
This paper emphasises the importance of global teams in the field of software development. The paper presents an approach for setting up pilot studies simulating those key features that make global software development teams particularly attractive to exploit and challenging to manage. The underlying research is supported by a research project funded by the US National Science Foundation with the participation of universities from US, Turkey, Panama and the UK. The paper provides detailed guidelines for setting up simulations resembling globally dispersed software development teams and discusses preliminary data of two pilot studies with involving collaboration between teams residing in the US and the UK. Key concerns of this research are those factors affecting collaborative work when global teams are involved. Such factors include differences caused by distance, culture, time zones and technology.

KEY WORDS
Global teams, software development, collaborative work

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1. Introduction
The modern software development industry has witnessed the introduction of new models of collaborative work, primarily due to the advances of collaborative technologies and the availability of infrastructures supporting remote work. According to Vaclav Havel, “it is necessary to change and improve our understanding of the true purpose of what we are and what we do in the world. Only such a new understanding will allow us to develop new models of behaviour, new scales of values and goals, and thereby invest the global regulations,
Outsourcing was becoming a frequent solution to reduce differences with IBM employees in 53 countries [10]. Software teams investigated Hofstede’s work on cultural differences with IBM employees in 53 countries [10]. Outsourcing was becoming a frequent solution to reduce costs and maximize the effect of the ‘round the sun development’ with carefully located geographically dispersed teams simulating a shift based pattern of collaborative work. Apparently team formation and role allocation issues are critical for the success of such work practices [11].

An interesting aspect of cultural differences and how they may affect outsourcing and offshore projects is provided in the literature. Dibbern et al (2008) discuss the inherent costs of outsourcing leading to the failure of such projects, focusing on control, coordination and knowledge transfer [35].

Hildenbrand et al (2008) identify a current assumption for “necessary industrialization of software development and design of novel forms of specialization, task distribution, and collaboration”. The authors provide a classification and evaluation of current approaches of collaborative software development [34]. Apart from these documented approaches, there are also ad hoc efforts from major industry players towards the evolution of Distributed Software Development and outsourcing of certain types of tasks.

IBM along with BT has invested in outsourcing and remote work structures over several decades. It is fascinating to observe IBM being one of the pioneering forces introducing its Second Life Grid, a platform enabling organisations to create “a public or secure private space using the leading 3D online virtual world technology… to hold virtual meetings and provide employee training” (http://secondlifegrid.net/). One would expect that sooner or later the Internet would provide the means for such radical approaches; however the interesting part is the theme of the demonstration taking place at IBM Second Life islands (the equivalent of private space in the Second Life platform) since IBM employees were against forced outsourcing.

2. Relevant Work

It should be obvious that outsourcing is here to stay so instead of stretching management techniques to fit the new requirements it is important to shift management protocols and educate individuals towards a new breed of employees. The new environment requires people to introduce technology in their daily lives as it happened with the use of email in the 90s. Practitioners and researchers alike found the grounds for applied Information Technology research and development further extending the fields of computer supported cooperative work and Groupware that were introduced in the late 80s. Groupware technologies such as synchronous and asynchronous discussions, video conferencing, e-mail, voice mail and electronic meeting systems make it possible for teams to communicate and collaborate across distance and exchange from one time zone to another [5] [26].

Such practices supported by plethora of technological tools made it possible to establish global teams that were heterogeneous in nature and were structured either with a core team and several team members being geographically dispersed or truly globalised without a centre but with all members linked through a complex communication and interaction network. Such global teams are characterised from a number of unique features that differ significantly when compared with traditional collocated teams. Such features include distance (from each other), time-zone differences, and national culture (including language, national traditions, customs, and norms of behaviour) [1] [21] [25].
Early on it was perceived that these features could be identified as factors preventing teams from operating efficiently and causing negative impact on performance. It should be noted that global human resources were for years a concept met in software development departments and software engineers were the most common global workers. Instead of celebrating diversity as an opportunity to create versatile teams adaptable to volatile environments work focused on addressing possible needs of such teams. Collaborative software tools were designed to address the particular needs of global teams by enhancing communication, fostering a sense of community, and supporting the software engineering process [26] [1] [3] [6].

A key factor that is unique for geographically dispersed resources is the spatial-temporal distance among team members and the configuration of the members across different sites [4] [7] [30]. O’Leary and Cummings propose a list of spatial-temporal indices that account for factors such as a team’s size, distribution, use of technology, and its organizational structure [28]. Espinosa and Carmel were concerned with similar criteria when investigating the impact of distance, mode of interaction, and work overlap associated with software development [15] [16]. It is therefore argued that this study should be focused primarily on key criteria forming the spatial-temporal variables that are most appropriate for global team scenarios, including separation of resources (i.e. amount of travelling needed between team members) and overlap (i.e. the common working hours that collaborating human resources have). However, the team size, number of exchanging team members as well as number of could be additional causes of concern in global projects.

Along with the spatial-temporal distance criteria mentioned above, elements of culture have been addressed in the literature [5]. Culture has always been a difficult concept for researchers to contain in a scientific approach [25] [12]. Different perspectives regard culture in terms of cultural values including those traits associated with a specific country or national ethos [2] as well as those connected to a personal community [16] [24]. Literature on cultural difference provides interesting views when identifying determinants of culture that could be relevant to global teams [12] [22] [17] [19] [23].

In a global context, some individual characteristics are magnified when communication and interactions are affected by intrusive technology. Such characteristics could be as age, sex, race, education level, work experience, and organization tenure, some of which are informational attributes and others job-related [27] [33]. Existing work emphasised on how these differences increasingly impact on members of teams as the number and degree of differences within the team increases [34].

For example, gender and work experience often dictate how one thinks about and undertakes tasks [20]. Furthermore, demographic attributes such as education, previous knowledge, skills and work experience can influence what one perceives to be the mission of something as small as a single meeting or as large as a whole company [20].

3. Research Agenda

Based on previous research, the factors that seem to affect students enrolled in a global software development course are directly related to the spatial, temporal, and cultural distances that separate various groups. The proposed model combines research on global software teams with cross-cultural studies and recent research related to measures of temporal and geographical distance. According to this model, performance can be affected by a group’s individual, cultural, and spatial-temporal components. Furthermore, both the amount and kinds of effects that each of these factors has on the performance of global software teams may be related to the type of task that is performed.

3.1 Research methodology

It should be clear that our research agenda is giving emphasis on how distributed software development is affected by the nature of the tasks involved as well as issues relating to the team structure. The research methodology followed is based on analysis of spatial-temporal variables based on a selection of case studies.

One of the major factors in characterizing distributed groups is the spatial-temporal distance among team members and the configuration of the members across sites [4] [30]. O’Leary and Cummings propose a list of spatial-temporal indices that account for factors such as a team’s size, distribution, use of technology, and its organizational structure [28]. Espinosa and Carmel suggest similar measures in a study that examined the impact of distance, mode of interaction, and work overlap on different costs associated with software development [15] [16]. Thus, the spatial-temporal variables that seem most appropriate for this particular study are a team’s separation (amount of travel time among members of the team) and overlap (a measure of the group’s shared work hours), since the number of members in each group and the number of sites engaged in each project will remain constant throughout our study.

Along with spatial-temporal distance measures, different cultural components will also be considered [5]. Culture operationalise [25] [12]. In terms of our particular study, cultural values include those traits associated with a specific country or national ethos [2] as well as those connected to a personal community (e.g., school or region) [16] [24]. In our previous research, we examined
4. A Setting for Collaborative Work

the literature on culture in order to identify determinants of culture that could be relevant to global software development teams [19][23][27]. The result of this search was the selection of the Cultural Perspectives Questionnaire (CPQ) developed by Maznevski, et al. [23]. The CPQ measures a variety of respondent attitudes, from making decisions based solely on immediate concerns to the degree of belief in one’s destiny. While the attributes measured by the CPQ correlate well with culture, as validated in different studies [23], these attributes could also be viewed as personality traits (that just happen to be fairly consistent within cultural groups).

Individual characteristics are usually defined as age, sex, race, education level, work experience, and organization tenure, some of which are informational attributes and others job-related [27][33]. Studies show that these differences have an increasing impact on a group member as the number and degree of differences within the group increases [34]. For example, gender and work experience often dictate how one thinks about and undertakes tasks [20].

3.2 Research plan

Prikladnicki et al [31] describe in detail how qualitative research methods in software engineering affect research planning in DSD. Similarly, in order to understand more fully how cultural, spatial-temporal, and individual factors interact, we intend to test our theories on two different programming tasks: requirements definition and program/testing. This should allow us to answer some of the questions concerning the relationship between task type and our model. Our preference towards qualitative methods is advocated in the literature since it can provide more meaningful findings and informative results [32, 33].

We have identified a number of opportunities for designing pilot studies resembling DSD projects with significant differences in terms of distance, time zones and culture. Furthermore the fact that the research team was geographically dispersed, also resembling a cultural mosaic meant that more interesting findings were collected with respect to our collaboration patterns and communication styles.

Our research plan consisted of a number of key phases, including: (i) identifying suitable DSD projects as pilot studies, (ii) setting collaboration scenarios for participating teams, (iii) collecting data relating to communication and handing-off work, (iv) conducting a survey for the assessment of the DSD experience and (v) evaluating the case studies against the theoretical base used for the design of the pilot studies.

Although other variables may affect the performance of global software learning teams, we believe that the ones listed in this section are of immediate research interest. These factors were selected over other variables because they can be measured within this controlled environment. Another criterion is operational capability. Because of the nature of the tasks, the subjects (i.e., undergraduate students), and environment (i.e., programmers using computer-supported collaborative software), it is assumed that certain variables such as communication costs and office politics will not be factors in this research. Therefore, all of these variables will be made operational in the context of a specific task.

The principal investigators from the University of North Texas, Middle East Technical University, Atılım University, the Technological University of Panama, and Middlesex University in the UK will collaborate on the design and implementation of the proposed course materials. Advisors from Travelocity, Lockheed and IBM will assist us by insuring that the activities are both relevant and practical. Instructors will coordinate efforts through the web service infrastructure so that students can gain access to course materials located at each of the participating institutions.

Coordinating communication among students at the three universities as well as providing low-cost collaborative environments will be a major challenge for this project. The communication media need to support both informal and formal information exchanges [16][24]. Such activities can range from chatting about when a group should meet to designing software modules. The following section discusses the preliminary findings of the first two pilots between UK and US.

5. Key Findings

The project was initiated with two consecutive pilots between US and UK involving 62 students grouped in ten teams. The teams were balanced in terms of participation from UK and US students. There were no guidelines provided in terms of team leadership or coordination style. Both pilots were based on the same scenario with a fictional company contracting the US team for a development project and the UK team being sub-contracted due to time limitations of the project. The scenario was also based on the fact that the US team was more experienced than the UK team.

The scenario of the first pilot had Vehicle Rentals Ltd having contracting US Students Inc to design and develop a Database Management System for its transatlantic operations. US Students Inc has sub-contracted UK Students Plc to design a relational schema of the database tables based on the notes following an interview with the Managing Director of the Vehicle Rentals Ltd.
In the second pilot Vehicle Rentals Ltd has provided a follow up contract to UNT Students Inc for the design and development of the Database Management System. UNT Students Inc has again chosen to sub-contract MDX Students Plc for the delegation of some data manipulation tasks.

The time difference between the US and the UK teams were six hours and there were no common days of sessions. That meant that the US team had to create a dedicated session on the first Monday of each pilot to host management meetings. A kick off meeting was provided for students to familiarise with each other and for ice breaking. The initial meeting showed evident differences in terms of culture and perception between participating teams.

In terms of collaborative work the assumptions were the following: (a) the US team should be providing the UK team with the specification brief and clarification of the task requirements and (b) it was essential for both teams to communicate frequently throughout the pilots. Each pilot had duration of two weeks commencing on Mondays. The original messages for each task were scrambled to simulate possible communication and transmission problems. The UK team should identify their information needs and post them for the US team to answer. The fact that the UK teams would start the task late in the afternoon meant that an initial one day handicap was created by the pilot designed.

Key differences that were simulated in the pilots were the differences in experience, skills and knowledge between the teams. With the US teams at graduate level and the UK teams at foundation level this would resemble a more experienced team delegating less critical tasks to a sub-contracting partner. Also the communication protocol used was decided to fit one of the two teams and in order to monitor all interactions all other communication means were disallowed.

The students used three different types of communication, video conferencing, synchronous chat and asynchronous threaded discussion board. The communication would be initiated by the UK teams requesting more information and the US teams providing detailed working plans. In several occasions it was possible for the teams to host synchronous communication after scheduling such an event at the video conference session that was used to kick off each pilot. The intervention of instructions remained minimal to simulate project management techniques at this level in software development. Both US and UK instructors facilitated the video conferencing sessions and two briefings were offered at the end of the first week of each pilot to simulate interim project management appraisals.

Technical aspects of the collaborative work project included the different communication platforms that one of the teams (US) was using prior to the project. The fact that the team was experienced in such tools provided an expected outcome with minimum disruption, in line with industry norms. The second pilot provided an additional frustration for the collaborating parties with the task simulating a misalignment of required platforms causing a delay to the project. All teams were successful in dealing with the problem with the more experienced US teams taking responsibility of the interoperability tasks.

Data collection was an important aspect of the pilot studies and it was two fold. Initially, during the pilots the team activities were monitored through the virtual learning environment focusing on collecting information such as access times, total time spent in the task each session, number of sessions for each team member, navigation pattern leading to and moving from the team discussion, number of messages read, number of posts and actions to task files (see figure 1). Furthermore, evaluation data were also collected through two questionnaires focusing on cultural issues and their experience of working in a globalised context.

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During both pilots team members showed dedication in obtaining additional information and maintaining a healthy communication pattern with their collaborating team. As shown in figure 2, each team demonstrated a unique communication thread that could be easily used as a criterion to identify areas of concern and overall performance.

### Figure 1: Data collection

![Data collection](image1.png)

### Figure 2: Team communication patterns

![Team communication patterns](image2.png)

## 6. Discussion

Preliminary findings from the first two pilots indicate that some early hypotheses can be formulated with respect to culture, time zone differences, communication patterns, technological effects and collaboration issues.
It must be noted that most participating students are aware of cultural differences since the collaborating universities have impressively high percentages of international students. Therefore it was expected that team members would not have a cultural shock once the pilots would start. However it was evident that both cohorts were expecting a less culturally diverse student body on the other side of the Atlantic. These misperceptions were expressed through informal discussions with the instructors. In some teams culture caused some minor conflicts and affected slightly performance in terms of time needed to resolve conflicts. Surprisingly enough the only case of significant personality differences was caused among UK team members and after investigation it seems that could be attributed to team dynamics outside of the scope of this study.

The six hours of time difference was an interesting perspective of the pilot since most students experienced this obstacle to collaboration for the first time to such an extent. The introductory video conferencing session was proven quite useful since it gave the opportunity to familiarise with team members but also to prepare a schedule of meetings. Students found it quite useful to obtain each other’s schedule and set up windows of possible synchronous communication. After the first week it seemed that there were two types of teams, the ones that realised that time delays should have been incorporated to their working schedules and the ones that attempted to neglect the time zone element with devastating effects towards the deadline.

In terms of communication there were three main classifications of the collaborating teams. Highly interactive teams accumulated 70-80 messages for each pilot, with most teams having 40-50 posts relating to the tasks. Least interacting teams still achieved more than 20 posts in order to exchange vital information. Team members were not equally active and a clear pattern emerged with self-appointed team coordinators for each collaborating party. It is important to note that participants focused primarily on the task when communicating through the discussion board. Occasions where individuals attempted to use private communication tools were minimal since it was clear that the scenario would not accept such communication.

It seems that basic communication tools pose no longer a constraint to efficient collaboration as it was observed in previous work in the 90s. It is evident that chat and discussion facilities are mastered by certain age groups prior to their university experience. However it was necessary to regulate video conferencing sessions between the different teams. Further work should investigate further the use of such tools.

Finally collaboration between teams was based on working versions of the key document. There were two types of information exchange, one based on clarification comments and additional information and one relating to the working document. An important issue that was addressed with the help of the instructors was the delay in transmitting initial information in two teams. This issue was magnified due to the lack of synchronous communication and the number of hours each team remained idle due to the time zone difference. This factor will be an important one for future work with respect to the design of collaborative tasks.

7. Lessons learnt

Following from the discussion above, it became evident that the pilot studies have caused several concerns regarding the viability of global software development learning teams. The authors are aware of how inappropriate it would be to generalise the lessons learnt from these pilots and attempt to draw conclusions for global teams in the software development industry.

However, building on previous work of several funded projects that produced analytical results for various case studies in virtual settings and global team scenarios, certain lessons learnt are presented and classified as an initial partly tested set of guidelines for further pilot studies.

Quite early in the first pilot it was clear that maturity levels between collaborating students caused difficulties with respect to expectations, maturity, experience and code of conduct. It is necessary to align human resources since both team effectiveness and communication between individuals may suffer from differences in background, skills, knowledge and experience. This factor was derived from problem caused by the differences in skills and experience of the collaborating teams.

The kick off meetings for both pilots were based on synchronous communication that helped those teams that had most of their members participating in the ice breaking socialising part of the pilot. It seems that scheduling the synchronous meeting was a critical factor to distinguish team members according to motivation and interest. The emerged pattern showed that the more successful teams were the ones with their members attending all the synchronous meetings. This factor was derived from the significantly larger number of ice breaking posts in threads of those teams that did not participate in the synchronous meetings.

The use of multimedia richness to enhance communication and collaboration was critical to overcome the barriers of culture, experience, work pattern and understanding of the task. It was clear that the video conferencing sessions helped to establish rapport and further support collaboration in those cases where remote teams allowed some personal interaction in a less formal context. This factor was derived from evidence of
increased progress following the video conference and synchronous chat sessions helping team members to resolve conflicts and clarify misunderstandings relating to the task.

As in most student-based pilots the use of participation incentives becomes even more necessary. The volunteering nature of the project carrying a rather small incentive in terms of extra credit and a small prize meant that more students had the opportunity to opt out from the study. An interesting pattern emerged with participation being affected by the level of cohesion that different groups showed. Furthermore, it seemed that the second pilot (being closely related to the first one and following after a short break after the completion of the initial task) did not attract the same level of interest and there was inconsistency in terms of motivation for communication, collaboration and exchange of ideas. Based on some early feedback comments, it seems that interest levels were affected by the nature of the task (similar database projects), the team collaboration pattern (the less active members failed to integrate even if it was only for the second pilot) and the rigid induction process (although synchronous meetings were offered for the second pilot, it was difficult for least involved team members to catch up and identify their roles). This factor was derived from the different participation patterns of team members according to their perception of the provided incentives.

It seems that several teams were positively affected by individuals who showed a lot of enthusiasm leading to heroic efforts and personal intervention. These teams were the ones at critical stages of the collaboration certain key people from both universities would proceed and finish off the deliverables. They were proactive at undertaking a team leader or facilitator role. This factor was derived from those teams that included individual team members undertaking full responsibility towards the end of the task in a completer-finisher role.

Another critical aspect that affected all teams during both pilots was the dissemination of information that was based on the briefings posted on the virtual learning environment. The fact that part of the message was initially scrambled and that time zone differences posed a six hour delay meant that collaboration was significantly affected. This factor was derived from the communication of team members with the research team seeking further opportunities of briefings, leading to a number of additional briefing sessions.

There is need to further research interaction and communication patterns of participants. For example some inconsistencies were observed with respect to loafing in different teams. Mr S.A. read 267 articles and posted 66 while Miss R.A. read 1016 followed by 28 posts with the worse example of loafing being Mr M.A. with 5119 items read and only 2 posted messages! Altogether there seems to be an association between the reading and posting patterns. There is also a correlation between the time spent in the environment and the reading of the communication within the team but not with the number of posts. It seems that a significant part of the team spent their time mainly for reading the specification and clarifying the task. This factor was derived from the different results and progress monitored in teams with significantly different communication patterns in terms of consistency, frequency and depth of information.

The task domain (databases) affects the end result of the communicating team since it is quite practical and requires less clarification after the initial briefing, installation and user help issues are covered. A more theoretical project would require further communication and decision making from the teams. This factor was derived from the different communication patterns followed for different tasks.

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<tr>
<th>Factors</th>
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<tr>
<td>Alignment of human resources</td>
<td>TF/RA/MC</td>
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<tr>
<td>Synchronous communication</td>
<td>TF/MC/CM</td>
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<td>Multimedia richness</td>
<td>CM/CL/MC</td>
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<td>Participation incentives</td>
<td>RA/CL/MC</td>
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<td>Interest levels</td>
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<td>Personal intervention</td>
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<td>Information dissemination</td>
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Table 1: Factors affecting global teams

Furthermore, the design of any deliverables should be based on the needs of each team rather than the task leading to clear agenda items for each meeting that are owned by the different teams. This factor was derived from the communication patterns following a structure similar to the one required for the deliverables. Progress assessment should be also based on the different goals of each team rather than the task overall goals. This factor was derived from the different agenda present in the collaborating teams.
As shown in figure 3, the factors affecting global teams and influence DSD can be classified according to the two key variants concerning this project, namely task and team complexity. One of the objectives for the remaining two years of the project will be to identify ways of measuring and providing a more accurate classification of such factors. In the figure the horizontal axis shows how these factors relate to the complexity of the task in hand. The vertical axis prioritises the factors affecting global teams according to the structure, communication and collaboration complexity of the team.

8. Future Work - Towards a Third Pilot

From the previous sections it is evident that a number of factors affecting DSD and the work of global teams can be identified and their prioritisation may differ significantly depending on the structure of teams, the project tasks and external influences. Our experiences with the first two pilots concluded that it is important to investigate further our hypotheses in more realistic scenarios of distributed development, allowing alternative team structures and focusing on tasks from different stages of the lifecycle, including requirements capture, design and programming, proving more demanding than testing in the way teams collaborate and communicate.

The previous section provides an overview of the findings and lessons learnt from the two pilot studies between US and UK teams. A different project was assigned to teams residing in the US, Turkey and Panama. The three teams were asked to develop a system that could be used to create and manage groups. Each country team was asked to deliver one of the components for this system. Each country team’s deliverable was further refined into sub components which could be assigned to individual members of the country team. All three teams were required to collaborate on a common interface that supported each of their individual components.

Although the factors affecting global teams were identified prior to the beginning of the third pilot they did not affect the design of the task. The aim of the project is to identify different collaboration settings and a variety of tasks that are feasible in global software teams. The identification of issues relating to role allocation, team formation, management and coordination of such teams will have a different weighting according to the task and team structures.

9. Conclusion

This paper provided the basis for further work in global software development teams. The paper discussed the research foundation and provided an overview of the key aspects for the underlying research. It seems that setting up global team simulations is feasible in an educational context but certain difficulties exist when aligning curriculum, working ethos, deadlines and incentives. It is envisaged that the research outcomes could be (after the evaluation of the industrial patterns) providing evidence of good practice and guidelines for projects exploiting the positive effects of global teams and dispersed resources.

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