The Engineering Project Organization Journal (June 2011) **1**, 121–141

Routledge
Taylor & Francis Group

Enabling conditions for the emergence and effective performance of technical and cultural boundary spanners in global virtual teams

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Received 13 December 2010; accepted 14 March 2011

Globalization has led to a widespread increase in the practice of 'offshore outsourcing' of projects in the construction industry. This phenomenon has led to the development of a new form of organization—the 'global virtual team'. Where much is explored in the extant literature on the ingredients affecting virtual team functioning, relatively little research has been done on the interaction of participants in virtual teams, the role of boundary spanners that bridge occupation and cultural boundaries and their impact on project performance. Motivated by this understanding, a research experiment was conducted wherein postgraduate engineering students from IIT Madras, India and Columbia University, USA, collaborated virtually to develop a computer-aided design model and an organizational simulation model of ongoing construction projects in the USA. We used social-network analysis to examine the performance of four teams that executed this academic exercise virtually over a period of three months. Team fraternization, richness in communication and the presence of individuals who share attributes across sub-teams were found to influence the boundary spanning process and impact project performance. Greater fraternization among virtual sub-teams led to the emergence of technical boundary spanners (TBSs) who were able to bridge technical and work-related differences. The presence of a rich face-to-face communication environment and team members who shared attributes with both cultural sub-teams led to the emergence of cultural boundary spanners (CBSs) who helped bridge cultural differences in real time. TBSs enabled successful completion of project tasks whereas the combined competence of both the TBSs and the CBSs led to project success and effective team performance. Finally, we propose a theoretical model depicting the enabling conditions that induce members to emerge as technical and CBSs.

Keywords: Boundary spanning, construction management, cultural issues, global projects, virtual team dynamics.

Introduction

Offshore outsourcing of services for delivering global projects is a trend that is currently driving organizational change in the architecture, engineering and construction (AEC) industry. Using information technology as the primary enabler, organizations are trying to adapt quickly to dynamic networks, competitive landscapes and customer requirements (Miles and Snow, 1986; Jarvenpaa and Ives, 1994; Powell *et al.*, 2004). Even though technological support for virtual teams and collaboration in distributed environments is now viable and widespread (Constant *et al.*, 1996), researchers contend that the practice of offshore outsourcing is all the more challenging in engineering services delivery where global project networks of firms deal with a multitude of tasks, specialization, resources and various kinds of boundaries to execute complex and reciprocally interdependent projects (Nayak and Taylor, 2009). Extant literature addresses the issue of how emerging technologies promote collaborative work in teams dispersed across space, time and national–cultural boundaries. However, Chinowsky and Rojas (2003) argue that little guidance currently exists to assist the stakeholders in the construction domain in the successful implementation and management of virtual teams.

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The Engineering Project Organization Journal
ISSN 2157-3727 print/ISSN 2157-3735 online
http://www.informaworld.com
DOI: 10.1080/21573727.2011.572964

Saunders (2000) demonstrates the life-cycle model of a virtual team organized around four categories of variables: inputs, task processes, socio-emotional processes and outputs. Powell *et al.* (2004) has extended this model by identifying specific parameters that fall under each category, such as the communication and coordination that must accompany task processes, or the trust and relationship building that should accompany socio-emotional processes. We note from this model that the task and socio-emotional process modules are mediating variables and require greater focus in virtual team studies.

Subsequent studies on the process module have thrown light on other parameters such as the role of participants in the process and the significance of understanding how members identify each other's competencies and consult each other, thereby building a map of the emerging social network within a virtual project team (Malhotra *et al.*, 2007; Chinowsky *et al.*, 2008; Chinowsky *et al.*, 2010). Behrend and Erwee (2009) as well as Chinowsky *et al.* (2010) contend that the emergent social network delivers information on members' influence, prestige, specific team member-related brokerage roles and the boundary spanning information and knowledge sharing activities they are engaged in during the team process. This then impacts project performance. Levina and Vaast (2008) argue that research on this boundary spanning phenomenon has drawn significant attention in the recent past due to the growing complexity in virtual team projects.

A review of the literature reveals that boundaries are created within project sub-teams due to the inevitable conflicts in global projects that impede effective performance (Chan and Tse, 2003; Hinds and Bailey, 2003; Bryant, 2006; Mahalingam and Levitt, 2007). Several researchers have identified the critical role that boundary spanners can play in increasing the efficiency of knowledge exchange across teams and organizations and in resolving conflicts that emerge due to weak interpersonal ties (Friedman and Podolny, 1992; Cross and Prusak, 2002; Behrend and Erwee, 2009; Chinowsky *et al.*, 2010). The boundary-spanning phenomenon requires individuals to cross boundaries to resolve conflicts and bridge the needed information between the teams. Levina and Vaast (2005) contend that boundary spanners can be individuals from within the team who can emerge in practice by the creation of a new 'joint field'. Espinosa *et al.* (2003) stress the need for members to bridge and span boundaries effectively to do their work. They identify five types of major boundaries—geographical, functional, temporal, identity and organizational—and discuss the need to study other boundaries such as cultural, technological, expertise and political to corroborate and extend their findings. DiMarco *et al.* (2010) build upon Espinosa *et al.*'s (2003) suggestion to consider cultural boundary spanning and Levina and Vaast's (2005) work on the emergence of the boundary spanners and discuss the emergence and role of cultural boundary spanners (CBSs) in resolving knowledge systems conflict in global project networks. They too contend that the creation of a new joint field is of strategic importance and can enable team members with differing national–cultural backgrounds to negotiate the occurring conflicts and pursue common goals. This leads us to recognize boundary spanning as a key construct that affects virtual team performance in global projects.

DiMarco *et al.* (2010) identify the various categories of knowledge systems conflicts that surface during face-to-face cross-cultural interactions and the role performed by CBSs to resolve these issues. They also focus on the emergence of CBSs in practice and discuss project-based triggers that activate the CBS. However, relatively little attention has been paid to the structural and background conditions that can lead to certain individuals emerging to take up boundary spanning roles. Furthermore, DiMarco *et al.* (2010) primarily consider rich communication environments and focus exclusively on the emergence and role of a CBS. The potential for other kinds of boundary-spanning capabilities in environments with differing levels of communication richness has not been investigated. *We thus argue that we need to build upon DiMarco et al.'s (2010) and Levina and Vaast's (2005) ideas to explore the boundary-spanning phenomenon in greater detail. Specifically, we need to augment our understanding of the team dynamics that can enable individual actors to emerge as boundary spanners in practice, the types of boundary spanners that can emerge, conditions contingent for their emergence and their effect on project outcomes*.

Our research is motivated by two directions that emerge from the literature. First, an empirical analysis of within-group social network dynamics is essential to our understanding of virtual teams (Chinowsky *et al.*, 2008; Behrend and Erwee, 2009). Second, it is possible to systematically investigate and identify the enabling conditions (Gibson and Cohen, 2003) that can promote the emergence of boundary spanning and develop informal networks to enhance team effectiveness (Cross and Prusak, 2002; Levina and Vaast, 2005). In order to operationalize our research goals, we propose a study model based on the above literature that extends Powell *et al.*'s (2004) model on virtual interactions. Our study model is shown in Figure 1 and introduces 'team processes' and interactions as a mediating variable that affect both the actual task and the socio-emotional processes—factors identified by Powell *et al.* (2004) as the two key processes that influence the outcome of virtual teams—and, thereby, the outcome of the project.

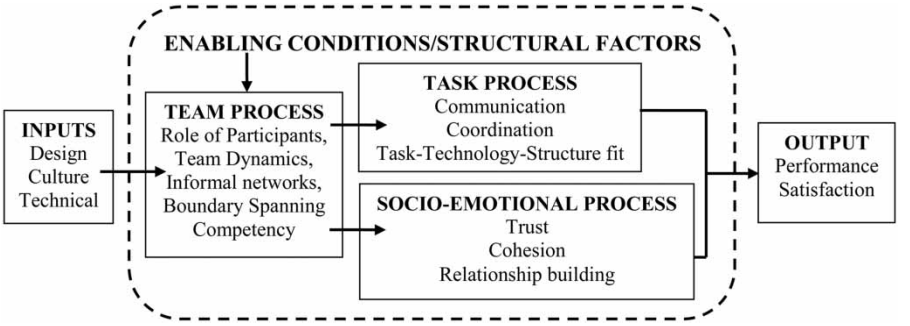


Figure 1 Proposed study model

Work by Espinosa *et al.* (2003), Levina and Vaast (2005) and DiMarco *et al.* (2010) clearly identify 'Team Processes', and the presence of boundaries and boundary spanners to be a mediating variable that helps virtual teams achieve successful outcomes. We thus plan to combine these frameworks with Powell *et al.*'s (2004) model to study the task and socio-emotional performance of project teams and analyse the emergence and effectiveness of boundary spanners in achieving project outcomes.

In particular, we attempt to answer the following research questions that then stem from this model:

1. What are the key enabling conditions and structural factors that affect the team process that then impacts the task and socio-emotional process performance?
2. What are the conditions which can enable team members to emerge as boundary spanners impacting team performance and project success?

Research setting and methods

A synthetic experiment was conducted involving post-graduate engineering students of the Construction Management Division at IIT Madras (IITM), India and engineering students from Columbia University (CU), USA. Several of these participants possessed field experience. The project took place for a period of three months from February 2008 to April 2008. A total of four global virtual teams were examined and their interactions studied. Each team consisted of nine members: four CU and five IITM members. The teams took up an ongoing construction project in the USA to execute the task as described below:

Task for the participants

The CU members of each team were responsible for communicating project data to their Indian counterparts to enable them to develop a 3D computer-aided design (CAD) simulation model for the given project. IITM team members used AutoCAD for this purpose. With the same data, the CU members had to develop an organizational simulation model using SimVision^{TM} in order to predict project duration and participant backlogs. The project schedule developed by the CU members was later utilized by their Indian counterparts to develop a 4D CAD model for the project using Common Point^{TM}. Participants were then required to work as a team to suggest interventions to optimize project performance. Time–space improvements identified in the 4D CAD model would require changes in the project schedule, which in turn would impact the organizational simulation model. A final project plan therefore needed to be iteratively developed between participants from both IITM and CU. The exercise culminated with the teams presenting a common report to both the universities explaining their experience and interventions during the work process and the final results. The entire process was dynamic, iterative and reciprocally interdependent.

Team composition, structure and interaction

Researchers stress the need to carefully set the bounds of interaction space (Garud and Kumaraswamy, 2005; Vadhavkar and Mora, 2009). The four experimental study teams designated as Team 1, Team 2, Team 3 and Team 4 were designed to be teams setting their own protocol (Vadhavkar and Mora, 2009). They were provided with no specific guidelines as to how they must collaborate and respond, to enable us to capture the group dynamics as it grew organically during the process. Communication was carried out through emails and chat software such as Meebo, Gtalk and Skype. Participants chose a platform based on their convenience. The participants interacted to exchange information regarding the project and their models. They also interacted on combining their models to come up with interventions that could

optimize the project. In order to do so, they had to communicate technically. In addition, the teams also engaged in some amount of non-technical communication. The communications that related to the task process were thus categorized as technical and those that related to the socio-emotional process based on Powell *et al.*'s (2004) framework were characterized as non-technical.

When composing the teams, Teams 1 and 2 had one participant each in the CU sub-team who was of Indian origin. These two actors were deliberately placed in separate teams in order to observe whether their shared national background on the one side and their shared academic affiliations on the other would enable them to play a boundary spanning role as the project progressed. Further, two out of the four teams did not have a boundary spanner (a member with shared attributes) and we therefore hoped to observe differences between teams with and without such actors. The boundaries that were assumed to exist at the start of the actual experiment were geographical, temporal, organizational, linguistic, technological (due to different technologies used) and cultural. We were more interested in studying the technical and cultural boundaries. This is in line with comments made by Espinosa *et al.* (2003) who state that such boundaries could also affect the outcome of virtual project teams, and must therefore be investigated.

Data analysis methodology

The data for analysis consisted of emails and chat transcripts collected during the exercise. The data were analysed quantitatively and qualitatively. Bertoloti and Tagliaventi (2007) contend that qualitative and quantitative data offer distinct, but complementary insights into team dynamics, supporting the view that understanding virtual team processes requires a multi-faceted research approach. Qualitative data were derived through participant-network observation, inline study of transcripts of team events and intervention reports. The analysis was based on network interpretation and group dynamics (Maznevski and Chudoba, 2000).

In trying to analyse the interactions between team members, social networks analysis (SNA) emerged as a useful tool. Social networks are an often ignored component which can aide in understanding the subtle tacit knowledge that resides within teams (Nonaka, 1994; Cross and Parker, 2004; Liebowitz, 2005). SNA is a set of mathematical and statistical techniques for handling relational data which aid in identifying the structural properties of sets of relations and visualizing networks. The mathematical basis of SNA is graph theory and matrix algebra (Scott, 1991, 2000). SNA can be used to formally map knowledge flows and measure relationships between actors in project-based organization networks (Hanneman, 2001; Taylor and Levitt, 2004; Chinowsky *et al.*, 2008; Behrend and Erwee, 2009; Chinowsky *et al.*, 2010; DiMarco *et al.*, 2010). Our social network-based quantitative analysis was done using UCINET 5 for windows, PAJEK and Net Draw SNA software tools (Borgatti *et al.*, 1999; DeNooy *et al.*, 2005. SNA allowed us to capture metrics such as network density, centrality, structural holes and strength of ties (Wasserman and Faust, 1994; Chinowsky *et al.*, 2010) that allowed us to understand team-interaction dynamics. These metrics are briefly described below:

(1) Network density indicates the amount of interaction that exists between the team members. If everybody were to be connected to everybody else on a team, the density would be a perfect 1. Density reflects the number of actual links that exist between members in comparison with the number of potential links that exist if all members were connected.
(2) Centrality is associated with power in the network. There are three important centrality measures.
    (i) Degree centrality (C_D): this measure counts the number of ties to other actors in the network needed to transfer knowledge.
    (ii) Betweenness centrality (C_B): this measures the amount of information that is routed through individual during team discussions.
    (iii) Closeness centrality (C_C): this measure indicates the degree to which an individual/actor is near all other individuals in a network. It reflects the ability to access information through the grapevine of network members.

Table 1 depicts the mathematical expression used to calculate each of these centrality measures as put forth by Wasserman and Faust (1994). Note that in these formulas, 'g' is the total number of actors and '$d(n_i)$' is the degree of the ith node (individual actor). From the centrality measures, we calculated the density of the network relation, which is the average standardized degree of these three measures.

(3) Structural hole: a member who provides the missing links between two subsets of a team. He/she is also known as a gatekeeper (GK)/representative (R)/boundary spanner and is found to bridge the work within and outside an organization (Espinosa *et al.*, 2003).
(4) Strength of ties: a distinction lies between weak and strong ties. A link is stronger to the extent

Table 1 Mathematical representation of centrality measures (Wasserman and Faust, 1994)

Centrality measures	Actor centrality	Relative centrality/standardization
Degree centrality (C_D)	$C_D(n_i) = d(n_i)$	$C_D(n_i) = d(n_i)/(g-1)$
Closeness centrality (C_C)	$C_C(n_i) = g[\Sigma d(n_i, n_j)]^{-1}, j = 1$	$C_C(n_i) = (g-1)\ C_C(n_i)$
Betweenness centrality (C_B)	$C_B(n_i) = \Sigma g_{jk}(n_i)/g_{jk}, j < k$	$C_B(n_i) = C_B(n_i)/[(g-1)(g-2)/2]$

Table 2 Observed interaction in teams

Team no.	Frequency of meetings scheduled (over Skype/Gtalk/Meebo)	Total number of interactions observed (in email and text chat sessions[a])
1	Twice in February, once in March and none in April	149
2	Twice in February and twice in March	82
3	Once in February, March and April	92
4	Once in February, March and April	141

[a]Discussions on different topics were counted as separate interactions when analysing the chat and email transcripts.

that it is closer in distance and is relied on more extensively, usually characterized by deeper trust and commitment. Depending on circumstances, weak ties can be just as important as strong ties (Granovetter, 1973).

Data collection and data mining

The four experimental teams were required to schedule their meetings for transfer of information. Teams 1–4 interacted over voice/text chat facilities (Skype/Meebo/Gtalk) nearly three to four times on an 'as needed' basis during the entire three-month period. The rest of the interactions were over emails. All the communications related to this exercise were documented and coded based on variables related to team dynamics. The coded transcripts were further segregated into interactions based on technical communications (task related) and non-technical communications (socio-emotional process related) for in-depth analysis. The latter were informal and formed the social-network dynamics prevalent in a team (Scott, 2000; Chinowsky *et al.*, 2008; Behrend and Erwee, 2009). Table 2 summarizes the frequency of meetings held by each team and the total number of interactions observed during the process.

The constructs that were used for coding are listed in Table 3, whereas Tables 4 and 5 explain the variables for technical and non-technical communications briefly and state the justification for categorization.

Team analysis

Team analysis on virtual interactions was conducted at two levels, within and across the teams as stated below (Contractor and Monge, 2002).

1. Within each team: this process consisted of segregating the data month-wise, in terms of technical and non-technical communications/interactions. The quantitative analysis was then done across the months within the team, starting from February to April by converting the coded transcripts into a matrix format and running SNA software tools on this data. This resulted in generating six sociograms (one for each month for technical and non-technical communications) and computing the associated SNA metrics for each team. This level of analysis helped us understand the group formation pattern within the teams every month and the participants' team dynamics as they proceeded from start to the completion of the project.
2. Across the four teams: with the availability of data on four teams, we were able to compare and contrast the performance of one team with the other. Given a general platform and a similar set of circumstances, each team was found to vary in their approach. This allowed us to draw significant qualitative inferences on the factors that affected team performance.

Face-to-face interactions

Prior to the commencement of the exercise, it was decided that Teams 2 and 4 would also have face-to-face interactions in India prior to the closure of the exercise. These two teams thus had a varying degree of virtuality—virtual and direct interactions. The CU students of these two teams came down to IITM for a three-day face-to-face interaction with their Indian sub-team members during the first week of May 2008.

Table 3 Variables for data coding

Constructs based on technical communications	Variable code	Constructs based on non-technical communications	Variable code
Communication method	COM	Fraternization	FRT
Urgency	URG	Confusion	CON
Terminology	TER	Time zone difference	TZD
Technology	TEC	Leadership	LDR
Team communication/discussion	TMC	Anger	ANG
Task requests	TSK	Lie	LIE
Time constraints	TIM	Expressing culture	CUL
Lack of necessary info	INF	Scheduling	SCD
Understanding	UND	—	

Table 4 Description of variables: technical communication

Code	Code description
COM	Discussion on the use of communication media to transfer data and discuss technical aspects of the project
URG	Comments surrounding requests for data or for module completion, couched in language indicating that it is imperative for a team to receive this information for timely task completion
TER	Requests for terminology clarifications due to the observed institutional differences
TEC	Communication-related technological difficulties experienced by team members while discussing the technical aspects of the project
TMC	Discussion within the team to understand the task progress and processes to be adopted
TSK	Team request for technical information to start execution of a task
TIM	Team communication to explaining difficulties in timely completion of the task
INF	Team expression on technical information necessary to complete a task
UND	Acceptance of responses to requests and clarifications for technical queries

Table 5 Description of variables: non-technical communication

Code	Code description
FRT	Socio-emotional bonding between teams consisting of pleasantries and other means that do not relate to the technical aspects of the project
CON	Lack of clear articulation and expression of thought during communication and team discussion
TZD	Expression of difficulty in coordinating the work due to time zone difference
LDR	Pro-active efforts taken to assign responsibilities, roles, processes or timelines
ANG	Communications reflecting dissatisfaction of the other sub-team, leading to blame
LIE	Purposeful miscommunication of fact or intent
CUL	Communications that explain a particular sub-teams viewpoint from a cultural perspective, thus bringing about a shared understanding of particular terminologies used during discussion
SCD	Communications relating to scheduling of meeting times common to all the team members for technical discussion

At the end of the three-day interaction, these two teams presented their work jointly. This experimental set-up allowed us to observe differences between virtual and co-located team performances. DiMarco *et al.* (2010) discuss the emergence and role of CBSs in global project networks by exclusively analysing the three-day face-to-face interaction of these two teams.

Findings on team interactions

Table 6 describes our research design and states the case specific conditions for each team. Our data and transcripts suggested that the teams by and large followed the following four stages to execute the assigned task: getting to know phase, data transfer and role allocation phase, project clarification and progress update phase, intervention discussion and report writing phase.

Team 1 findings

The distribution of the interactions between Team 1 participants both across months and between categories is given in Table 7. It is observed from Table 7 that in the month of February, the sub-teams discussed communication methods and technology constraints

Table 6 Case-specific conditions

Teams	Mode of interaction	Presence/absence of a boundary spanner in the team
Team 1	Only virtual interaction	Presence of a person with Indian origin in CU sub-team
Team 2	Virtual and post face-to-face interactions	Presence of a person with Indian origin in CU sub-team
Team 3	Only virtual interaction	Absence of any such person in CU sub-team
Team 4	Virtual and post face-to-face interactions	Absence of any such person in CU sub-team

and placed great emphasis on scheduling a common meeting time for voice chat. As the following quote from a CU sub-team member, indicates, this team desired to proceed with a nominated leader.

> CU1.1: Yes. I will be the team leader for the US team. I recommend that you select one for your team and that we funnel our communications through those two individuals.

The sociograms and the associated sociometric measures for technical and non-technical communications in the month of February are shown in Figure 2(a) and (b), respectively, with two actors/nodes (members from the CU sub-team) central in the network facilitating discussion between the sub-teams. It is observed that participant CU1.3, the CU member with an Indian origin is participative only during the non-technical communication[1]. During the month of March, team communication shifted from scheduling issues to discussing work assignments as observed in Table 7. Factors such as confusion, lack of necessary information or missing links in the project data were expressed by the sub-teams. The sociograms for the month of March and April for both technical and non-technical communications depicted one-to-one interactions due to the leadership style adopted by the team as shown in Figure 2(c).

In April, the team communications were characterized by various kinds of conflicts such as scheduling conflicts, conflicts due to time zone difference, time constraints, etc. The transcripts suggested that the team process had shifted from discussions on work assignment to a 'blame-game' scenario with the sub-teams expressing anger and blaming the counter sub-team for non-performance. The following extract from the transcribed text justifies the statement:

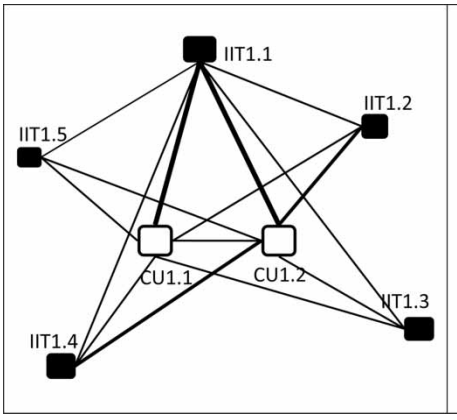
> CU1.1: You represented to me that you needed to have this project completed by 3/31/08, but I receive little response from you throughout the month of March and you indicated that your team was busy with other work. All I've heard from you is what you can't do. So far your team has contributed zero to this project.
>
> IIT1.1: Ok. You had sent me the PDF file in which you have identified 30 activities and I requested for MSP file in which all the task ID's are mismatching and even activities are irrelevant compared to the PDF file. Have you gone through the MSP before sending?
>
> IIT1.1: I would like to say that if the project site was from India, we would have contributed 100% and you zero by this stage. Getting information from site and forwarding the info to the counter part is the job which is to be done by the team residing in the respective country. Given this, you have sent me a junk of drawings and specifications.
>
> CU1.1: Right now I am very discouraged and disappointed with the level of support that your team has provided.

Conclusion on Team 1's performance

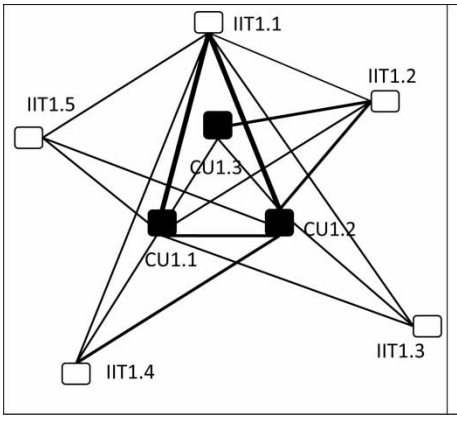
Our direct observations showed that Team 1 did not proceed beyond acquiring the project data and transferring this to their global team members. The network was

Table 7 Number of observed interaction in Team 1

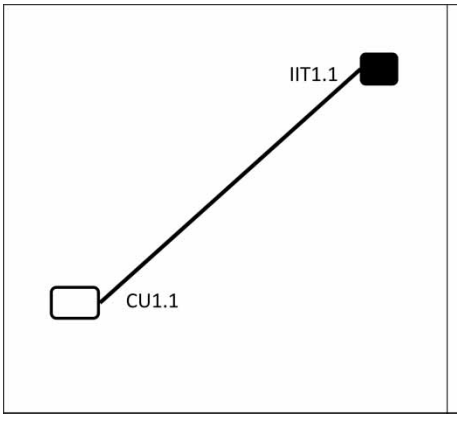
February		March		April	
Technical	Non-technical	Technical	Non-technical	Technical	Non-technical
TMC06	SCD35	COM01	CON05	TMC02	SCD09
TIM13	LDR11	INF03		TIM04	ANG07
TEC07	FRT02	UND05		URG02	TZD01
COM11		TMC24		COM01	
Subtotal = 37	Subtotal = 48	Subtotal = 33	Subtotal = 05	Subtotal = 9	Subtotal = 17
Total interactions = 149					



Participants	C_D	C_B	C_C
CU1.1	0.875	1.000	0.548
CU1.2	0.875	1.000	0.548
CU1.3	-	-	-
CU1.4	-	-	-
IIT1.1	0.750	0.800	0.333
IIT1.2	0.625	0.714	0.000
IIT1.3	0.625	0.714	0.000
IIT1.4	0.625	0.714	0.000
IIT1.5	0.625	0.714	0.000
Network Degree Centrality = 0.160			
Network Betwenness Centrality = 0.1389			
Network Closeness Centrality = 0.4714			



Participants	C_D	C_B	C_C
CU1.1	0.875	1.000	0.179
CU1.2	0.875	1.000	0.356
CU1.3	0.500	0.700	0.000
CU1.4	-	-	-
IIT1.1	0.875	0.889	0.179
IIT1.2	0.625	0.714	0.000
IIT1.3	0.625	0.714	0.000
IIT1.4	0.625	0.714	0.000
IIT1.5	0.625	0.714	0.000
Network Degree Centrality = 0.196			
Network Betwenness Centrality = 0.1428			
Network Closeness Centrality = 0.4714			



Participants	C_D	C_B	C_C
CU1.1	0.875	0.000	0.800
CU1.2	-	-	-
CU1.3	-	-	-
CU1.4	-	-	-
IIT1.1	0.875	0.000	0.800
IIT1.2	-	-	-
IIT1.3	-	-	-
IIT1.4	-	-	-
IIT1.5	-	-	-
Network Degree Centrality = 0.000			
Network Betwenness Centrality = 0.000			
Network Closeness Centrality = 0.000			

Figure 2 Sociogram/centrality measures: (a) technical communications in February, (b) non-technical communications in February and (c) team communications in March and April

not dense (network density being only 0.167 on a 0–1 scale) and cohesive even in the formative months. The minimal amount of fraternization in February makes us infer that the team did not give importance to relationship building. In the later months, it is evident that the team members could not overcome intra-team barriers and proceed towards project completion. Consequently, they failed to work on the model and execute

the required deliverables. The Indian member in the CU sub-team could not mediate between the sub-teams to resolve conflicts, probably due to the leadership style adopted by the team and the absence of shared understanding (Gibson and Cohen, 2003). The blame game at the end of three months and the associated animosity reflects upon the team's inability to perform their given task. It is possible that a lack of fraternization led to the lack of creation of a shared 'team identity' and that cultural and time-zone differences as well as communication difficulties deepened the faultlines (Cramton and Hinds, 2005) between sub-groups, leading to project failure.

Team 2 findings

Table 8 depicts the number of observed interactions for Team 2 in the month of February and March. It is to be noted that the data for the month of April for this team were unavailable for analysis.

During the month of February, the team discussed on communication methods and technology constraints, but also placed considerable emphasis on fraternization. The following extract from the transcript suggest instances of sub-team fraternization:

> CU2.1: How is everyone, and how is the weather over there! In class, we have named our group, team 2 in the US, as 'the Giants'. I'm not sure if any of you follow American football, but the Giants team just won the Superbowl, and is the greatest!! Did you guys have to name your team? If not, maybe we can call you guys the Giant's team in India, or the Indian Giants! Hopefully we can all come together to pull off a project completion as successfully as the football team!
>
> IIT2.1: We are happy to work with a cross-cultural team. Let's join hands with you people to bring about a great project. Do you guys play cricket?
>
> CU2.3: Yes I do like and play cricket. I think I could name the Indian players from the seventies through to now.
>
> CU2.1: Regardless of group chat room (thanks to IIT4 member), I do know, however, that by having a Gmail account, I see your photos (if inserted), and can chat informally when we 'see' each other too. It's useful to see the 'status/away' messages too, it helps me get a sense of 'who' you all are, i.e. personalities, philosophies, interests, how you're feeling about being swamped with school work at that particular point in time, etc. I currently especially like IIT2.1 saying 'The bliss of being ignorant …' with a photo of Pinky (from Pinky and the Brain).

Table 8 Number of observed interaction in Team 2

February		March	
Technical	Non-technical	Technical	Non-technical
TEC03	CON05	COM01	CUL01
COM14	SCD05	TEC03	SCD14
	FRT23	TMC05	TZD04
	LDR04		
Subtotal = 17	Subtotal = 37	Subtotal = 09	Subtotal = 19
Total interactions = 82			

The sociograms in the month of February for both non-technical and technical interactions were found to be cohesive as shown in Figure 3(a) and (b), respectively. The network had no isolates; all members were found to be equally participative. Researchers contend that this kind of cohesive formation is often the result of a harmonious team interaction (Wasserman and Faust, 1994; Scott, 2000). On comparing Teams 1 and 2 at this stage, we found that Team 2 had 23 instances of fraternization in contrast to Team 1 which showed only 2 instances of fraternization.

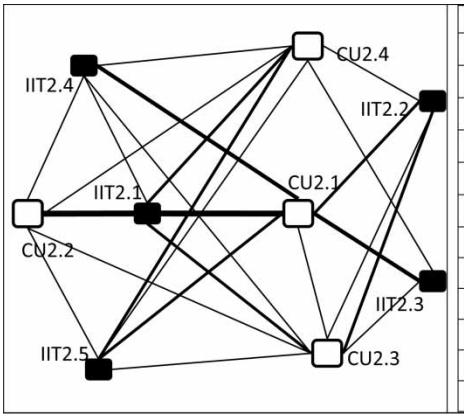
In the month of March, the non-technical team discussions appeared through two central actors, one each from the sub-team as shown in Figure 3(c), resulting in a star-shaped network. The transcript suggested that the two central actors chose to act as facilitators for information transfer rather than act as team leaders, which was the case in Team 1. The following extract is suggestive of their role allocation in the work process:

> IIT2.1: I (IIT2.1) and CU2.1 would be the communicators for the respective batches.

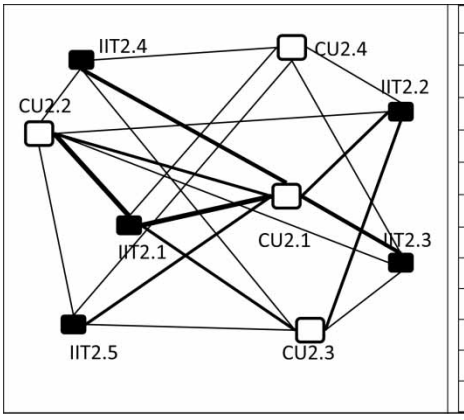
The non-technical discussions in March emphasized scheduling conflicts and conflicts due to time zone differences, etc., as observed in Table 8. The technical communications appeared to have transpired between the representatives of the sub-teams along with the CU project provider, CU2.2. Thus, the network is a straight line as shown in Figure 3(d) with high degree of stress on team representatives to transfer information to their respective team members (Wasserman and Faust, 1994). It is interesting to note that CU2.4, the Indian born member in the CU sub-team is found at the periphery of the network in Figure 3(c) during the informal communications in the team. The transcripts also suggest that this member was a passive observer and apart from exchanging greetings did not contribute much to the team discussion.

Analysis on face-to-face interaction post-April

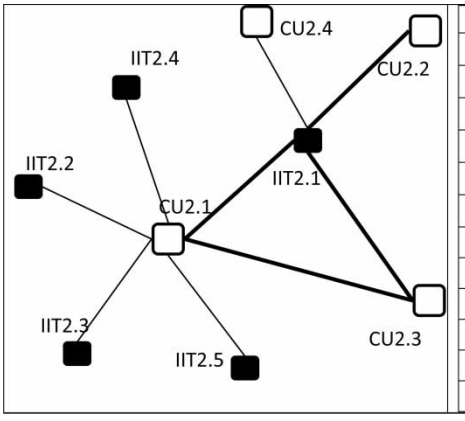
DiMarco *et al.* (2010) describe the emergence of CBSs in practice and the creation of a new joint field to resolve knowledge systems conflicts, in their work that analyses the three-day face-to-face interactions of this team in detail. From their study, we noted that Team 2 interactions on days 1 and 2 accounted for conflicts on cultural issues—knowledge system conflicts and



Participants	C_D	C_B	C_C
CU2.1	1.000	1.000	0.571
CU2.2	0.625	0.667	0.000
CU2.3	0.750	0.800	0.256
CU2.4	0.500	0.650	0.178
IIT2.1	1.000	1.000	0.571
IIT2.2	0.500	0.533	0.000
IIT2.3	0.625	0.700	0.000
IIT2.4	0.625	0.700	0.178
IIT2.5	0.500	0.650	0.000
Network Degree Centrality = 0.4107			
Network Betweenness Centrality = 0.5500			
Network Closeness Centrality = 0.7463			

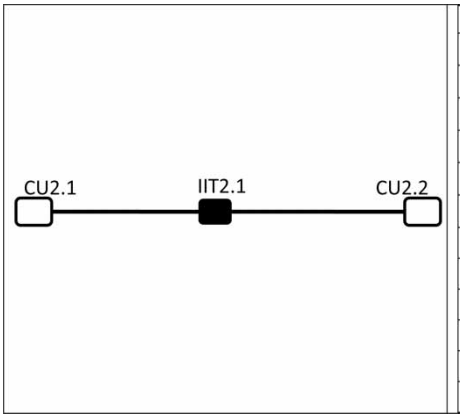


Participants	C_D	C_B	C_C
CU2.1	0.875	0.889	0.571
CU2.2	0.875	0.889	0.545
CU2.3	0.650	0.700	0.256
CU2.4	0.500	0.533	0.006
IIT2.1	0.875	0.889	0.571
IIT2.2	0.500	0.533	0.036
IIT2.3	0.625	0.700	0.036
IIT2.4	0.625	0.700	0.006
IIT2.5	0.500	0.650	0.006
Network Degree Centrality = 0.4500			
Network Betweenness Centrality = 0.4840			
Network Closeness Centrality = 0.5463			



Participants	C_D	C_B	C_C
CU2.1	1.000	1.000	0.545
CU2.2	0.625	0.000	0.167
CU2.3	0.750	0.143	0.286
CU2.4	0.500	0.000	0.167
IIT2.1	1.000	1.000	0.545
IIT2.2	0.500	0.000	0.167
IIT2.3	0.500	0.000	0.167
IIT2.4	0.500	0.000	0.167
IIT2.5	0.500	0.000	0.167
Network Degree Centrality = 0.4464			
Network Betweenness Centrality = 0.1023			
Network Closeness Centrality = 0.1841			

Figure 3 Sociogram/centrality measures: (a) non-technical communications in February, (b) technical communications in February, (c) non-technical communications in March, (d) technical communications in March, (e) day 2 sociogram: face-to-face interaction (reconstructed from Di Marco *et al.*, 2010) and (f) day 3 sociogram: face-to-face interaction (reconstructed from Di Marco *et al.*, 2010)



Participants	C_D	C_B	C_C
CU2.1	0.875	0.000	0.333
CU2.2	0.750	0.000	0.333
CU2.3	-	-	-
CU2.4	-	-	-
IIT2.1	1.000	1.000	0.800
IIT2.2	-	-	-
IIT2.3	-	-	-
IIT2.4	-	-	-
IIT2.5	-	-	-
Network Degree Centrality = 0.0535			
Network Betweenness Centrality = 0.0500			
Network Closeness Centrality = 0.6528			

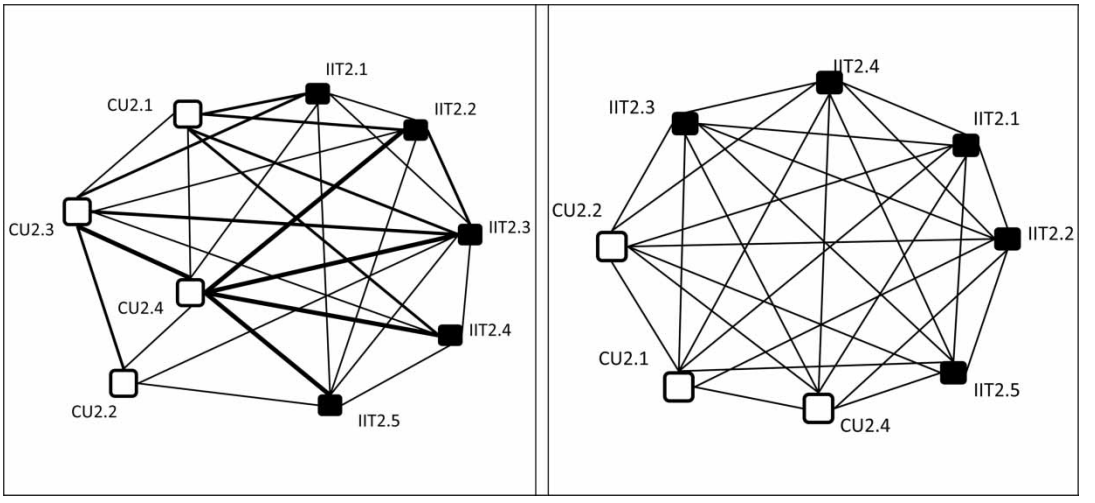


Figure 3 Continued

institutional differences in global projects as also pointed out by earlier researchers (Hinds and Bailey, 2003; Mahalingam and Levitt, 2007). Combining our observations with those of DiMarco *et al.* (2010), it appears that the CU team member of Indian origin, who was expected to play a boundary spanning role, was relatively inactive when the teams communicated virtually, but moved into a central position during day 2 of the face-to-face interactions as shown in Figure 3(e).

The participant CU2.4 is found to have played a key role in solving knowledge systems conflicts and helped the project progress. The following extract as also noted in DiMarco *et al.* (2010) highlights one such instance:

> CU2.3: Wait, wait, time out. What's a lorry?
> CU2.1: Dump truck. (Laughter)
> CU2.4: You use dump truck, here we use lorry.
> CU2.3: Okay.

The following instance describes a cross-cultural conflict due to differences in time conventions used. This was explained by CU2.4 to an Indian counterpart while resolving the conflict:

> CU2.3: The start date is June?
> IIT2.1: So you enter the date, its month, date-
> CU2.3: Month, date, year
> CU2.2: Yeah, it's opposite here.
> IIT2.1: Normally we do date, month, year, not like this.
> **CU2.4 and IIT2.1 converse in Indian language and CU2.4 explains how the Americans compose their dates**
> CU2.3: There's probably something you can do in here to change it.
> CU2.1: So everything I sent you was in month-date format.

Day 3 sociogram projects a cohesive and harmonious team network as shown in Figure 3(f). The team completed the project successfully and presented their interventions jointly.

Conclusion on Team 2's performance

The findings from virtual interaction suggest that the team's fraternization process in the formative months led to a dense (density of the network in February was 0.736) and cohesive network (Gibson and Cohen, 2003; Powell *et al.*, 2004). This created a shared identity that allowed team members to allocate roles for proceeding with the task process. Cohesiveness and density in the networks are therefore attributes that can have a positive effect on team performance. We further hypothesize that team fraternization enables cohesive network formation and triggers team members to span technical and administrative boundaries. CU2.1 and IIT2.1 in this case, who chose to be the communicators for their respective sub-teams, enacted the role of technical boundary spanners (TBSs) post-February. These actors did not merely transfer information back and forth as GKs/Rs would do, but attempted to translate the needs of each team to bridge technical difficulties that arose during the transfer of data. The following instance from the transcript captures the discussion between the two central actors spanning technical boundaries for project related information transfer:

> CU2.1: What is the information that you will need on the project?
>
> IIT2.1: Can you provide us with the information from the site, CAD drawings, resource schedule etc. We want you to select 25 activities and their time-schedule for our 4D CAD model. Can any one of you send us photos from the site so that we get a real feel of the project?
>
> CU2.1: CU2.2 will compile and provide the 25 activity list with the needed information you requested for 4D CAD. Keep in mind that it is still a proposed project (not out to bid yet), we will be estimating the resources. CU2.2 can send files through his office FTP site but cannot receive files through the same.
>
> IIT2.1: We will use Windows Live to send files from here and receive files from CU2.2's FTP site. I will send a test file through Windows Live.
>
> CU2.1: I think if we are able to meet this Saturday, it would be best. We are already behind in the required meetings and we need to allocate roles in terms of task assignment for all portions of the project.

In addition, the emergence of CU2.4 as a CBS who helped resolve knowledge system conflicts and steer the team towards project completion during face-to-face interactions suggests that enhancing the richness of communication triggered a dormant boundary spanner to take a pro-active approach and span cross-cultural boundaries. Enhancing the richness of communication can thus be an enabling condition triggering the emergence of CBS competence in practice.

Team 3 findings

Table 9 depicts the interactions observed from February to April for Team 3. During the month of February, the technical and non-technical communications were found to be almost equal. The team discussed communication methods, work assignment, scheduling meeting times, etc., apart from a nominal amount of fraternization.

The sociogram during February for both technical and non-technical communication is as shown in Figure 4(a). There are a few isolates who seem to only receive information (DeNooy *et al.*, 2005) and appear to be observers in the team process. We also observed that IIT3.1 from the Indian sub-team is central in the network whereas there is no central actor from the CU sub-team. All the members in the CU sub-team were equally participative with marginal difference in their degree centrality.

The transcripts suggested that the CU sub-team adopted the practice of summarizing the team meetings and always signed off as a team rather than as individual members, expressing team spirit while interacting. Further, the transcript also provided evidence to the intra team dynamics within the CU sub-team which was not evident in the analysis of other teams. The following is one such instance:

> CU3.1: CU3.2, have you sent the ppt. do we need a camera or something?
>
> CU3.3: I just chatted with IIT3.1 on-line and he is asking if we can change the time so it's at or later than 1800 IST. I told him I would have to talk it over with you all.

Table 9 suggests that there was minimal team interaction in the month of March. The network degree centrality was as low as 7% with only one participant interacting from the Indian sub-team as shown in Figure 4(b). The team was found to discuss on communication methods and the communication was more focused between a few team members.

April was suggestive of intense task related interaction, such as clarification on terminology issues, urgency to complete the task, time constraints, etc. The non-technical communication indicated that the CU sub-team offered to do more than their part even though 'anger' was expressed. The following instances from the transcript justify this:

> CU3.3: … We will gladly do the bulk of the paper if you provide us with at least a couple of pages detailing

Table 9 Number of observed interaction in Team 3

February		March		April	
Technical	Non-technical	Technical	Non-technical	Technical	Non-technical
TMC12	SCD09	URG01	CON01	COM09	SCD01
TIM02	LDR05	COM04		INF01	ANG04
TEC02	FRT09			TEC04	TZD01
COM10	TZD08			TER02	FRT01
				TIM02	
				URG01	
				TMC03	
Subtotal = 26	Subtotal = 31	Subtotal = 05	Subtotal = 01	Subtotal = 22	Subtotal = 07
Total interactions = 92					

your work so we can incorporate it into the paper and expand on it. We understand you have a large work load but please meet us in the middle here.

CU3.2: We also have other things to do! However we are all here working hard. We are being told we need to do a 25 page report but regardless a page and a half from the five of you is not even remotely acceptable. Even if 10-15 is enough that means you guys do between five and seven. We already stated we'd do the bulk. Just be fair and provide us with something with a little substance, again I re-iterate a page and a half between 5 people is ridiculous. If you choose not to contribute more, we'll have to hand in just our work, but we hope it won't have to come to that.

Figure 4(c) depicts the sociogram and the centrality measures for the Technical communication in the month of April.

Conclusion on Team 3's performance

This team completed the basic task of modelling but not the secondary task of designing the interventions and therefore failed to complete the overall project. The final stages of their project were characterized by some amount of frustration on both sides and the sub-teams attempted to complete the minimum project requirements of completing a model. This team did exhibit some level of fraternization. We also found that the sub-team representatives (IIT3.1 from the Indian sub-team and CU3.1 and CU3.2 jointly from the CU sub-team) played a key role in spanning technical boundaries by translating requirements, negotiating and mediating the exchange of information. The following extract is one of several instances of this:

CU3.1: Could you please explain what you are asking for when you ask for a 'more detailed service plan'.

IIT3.1: I want to know about the schedule also. Terms are confusing a little. Here in India the terms are a little different from what is mentioned. Can you send a detailed drawing explaining the terms. ….Due to time constraints we cannot build the 4D CAD model for the complete building, i.e. all the 3 phases.

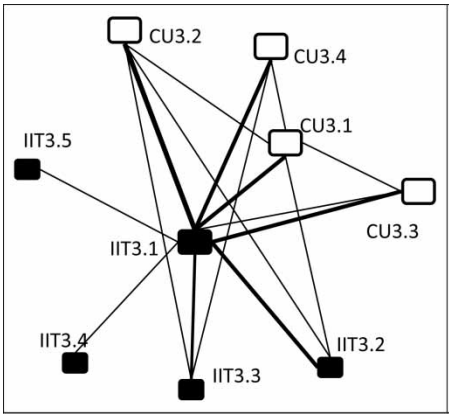
CU3.2: When will we able to view your model and have a discussion regarding the interventions we want to do? We would prefer to see the screen shots before we meet you to discuss on the interventions. And ultimately our paper is due on 22nd April, so we need it no later than 19th April.

Team 3's experience therefore seems to reinforce our learning from Team 2 and suggests that fraternization in the formative months triggers the emergence of TBSs who bridge technical information gaps across teams.

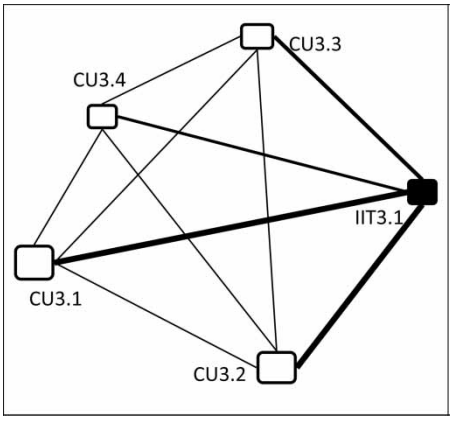
Team 4 findings

Table 10 depicts the number of observed interactions in each month for Team 4. In February, it is observed that the team discussed primarily on scheduling common meeting times during the non-technical communications. The technical communication was primarily on identifying appropriate communication methods for interaction. It is further observed that there was no instance of team fraternization in the formative month. Thus it appears that the team focused on executing the task rather than on rapport building. The sociogram for technical communication exhibited isolates as is evident in Figure 5(a). The network was not cohesive and the network density was only 0.315.

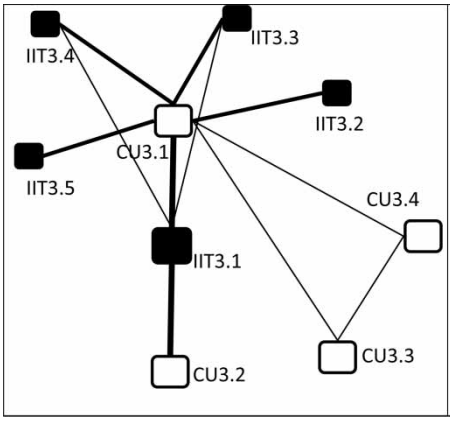
During the month of March, the team was found to be interactive on work assignment related issues such as time constraint discussions, technology constraints, project development, etc. The non-technical communication primarily addresses issues on scheduling conflicts. Figure 5(b) depicts the technical interaction in



Participants	C_D	C_B	C_C
CU3.1	0.750	0.256	0.270
CU3.2	0.625	0.445	0.270
CU3.3	0.500	0.256	0.270
CU3.4	0.500	0.256	0.270
IIT3.1	0.875	1.000	0.533
IIT3.2	0.500	0.256	0.270
IIT3.3	0.500	0.256	0.270
IIT3.4	0.425	0.000	0.006
IIT3.5	0.425	0.000	0.006
Network Degree Centrality = 0.3964			
Network Betweenness Centrality = 0.4651			
Network Closeness Centrality = 0.5384			



Participants	C_D	C_B	C_C
CU3.1	0.875	0.889	0.700
CU3.2	0.875	0.889	0.700
CU3.3	0.750	0.800	0.400
CU3.4	0.750	0.800	0.400
IIT3.1	0.875	0.889	0.700
IIT3.2	-	-	-
IIT3.3	-	-	-
IIT3.4	-	-	-
IIT3.5	-	-	-
Network Degree Centrality = 0.0714			
Network Betweenness Centrality = 0.000			
Network Closeness Centrality = 1.000			



Participants	C_D	C_B	C_C
CU3.1	1.000	1.000	0.256
CU3.2	0.875	0.377	0.173
CU3.3	0.625	0.264	0.122
CU3.4	0.625	0.264	0.122
IIT3.1	1.000	1.000	0.256
IIT3.2	0.500	0.000	0.006
IIT3.3	0.625	0.000	0.143
IIT3.4	0.625	0.000	0.143
IIT3.5	0.500	0.000	0.006
Network Degree Centrality = 0.3751			
Network Betweenness Centrality = 0.3294			
Network Closeness Centrality = 0.4151			

Figure 4 (a) Sociogram/centrality measures in February, (b) sociogram/centrality measures in March and (c) sociogram/centrality measures—technical communication in April

March. CU4.4 is observed to be the central actor in the network with a few isolates. The transcript suggested that CU4.4 was the information provider on the project and is thus central to the Indian sub-team.

In April, team communication was found to be predominantly technical. It is interesting to note in Figure 5(c) that IIT4.4 is suddenly central in the network. Evidence from the transcripts suggested that there was no focal point for communication and that different members pitched in with views at various stages where appropriate. The interactions were therefore relatively unstructured.

Analysis on face-to-face interaction post-April

DiMarco *et al.* (2010) demonstrate that Team 4 on day 1 of the interaction remained as two separate sub-teams and that no joint field was created as shown in Figure 5 (d). They state that the team was unable to establish a cohesive team formation during direct interaction due to the absence of a CBS and that they became more isolated on day 3 in contrast to Team 2 as shown in Figure 5 (e). They further argue that the conflicts identified during the direct interaction between the CU sub-teams and the Indian sub-teams were largely a function of the national–cultural boundary that separated them. This cultural boundary had to be bridged/spanned for effective collaborative performance (Espinosa *et al.*, 2003) even during face-to-face interactions. It is interesting to note from the sociograms that there was a decrease in the number of participants from day 1 to day 3 even though the collaboration took place face-to-face.

This understanding allows us to infer that if cultural boundary spanning was a barrier that both Teams 2 and 4 had to mediate, then even by creating an enabling condition, such as increasing the richness of communication, Team 4 could not be effective in their performance. This identifies the need for the presence of a boundary spanner, with some characteristics shared between each of the collaborating sub-teams to enact the role of CBS who fosters team cohesiveness, relationship-building and spans the national–cultural boundary to resolve knowledge system conflicts.

Conclusion on Team 4's performance

Team 4 had the benefit of direct interaction apart from virtual interaction. Despite this, the team only managed to complete the basic task of delivering the required models and did not complete the secondary task of identifying the interventions for successful project completion. Throughout the work process, both during virtual and direct interactions, isolates were found in the sociogram, suggesting little inclination from the participants towards team work and project success. The following extracts depict repetitions of the same discussion held across team members, indicating a lack of cohesion and information sharing within the team.

> CU4.1: What information do you need for the CAD model
> IIT4.2: General information, schedule, some pictures of the project. I think this information will be sufficient to get the project started.
> CU4.4: Does it have to be a Simvision. Can it be a different software?
> IIT4.1: Basically we need the time planned for the activity. It can be any format.
> CU4.2: IIT4.4. Is there anything else you can tell me about the CAD model?
> IIT4.4: We need the schedule files so that we can join with the 3D model to prepare the 4D CAD model.

During direct interaction, it is noted that the team network diagram did not depict a cohesive formation and there is no evidence of any member taking a proactive approach to steer the team to effective collaborative effort. Team 4 effectively functioned as two separate sub-teams. Thus, merely enhancing communication richness did not enable this team to emerge as a high performing team and did not lead to the emergence of technical or CBSs.

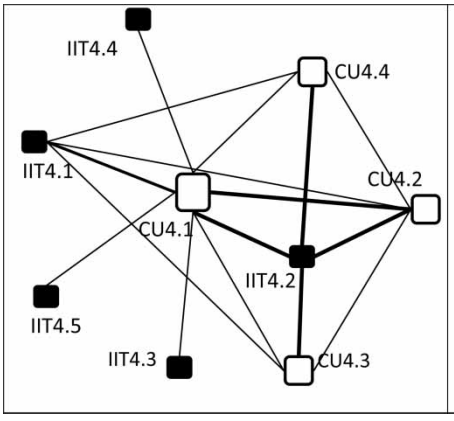
Discussion

Virtual team members are geographically dispersed, culturally diverse and work under varying time zones. The coordination, communication and scheduling challenges beset in such teams became evident in the experimental study conducted on the four teams. One team drastically failed to perform (Team 1), one excelled in their performance (Team 2) and the remaining two managed to complete the given task in its basic form

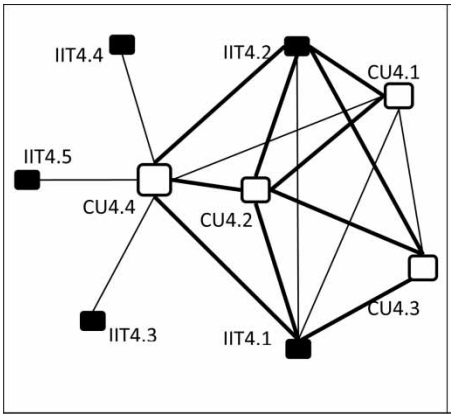
Table 10 Number of observed interaction in Team 4

February		March		April	
Technical	Non-technical	Technical	Non-technical	Technical	Non-technical
TMC08	SCD25	TMC05	ANG01	COM01	SCD06
URG02	TZD01	COM13	SCD22	UND03	
TEC05		TEC10		TEC05	
COM13		URG01		URG04	
		TIM01		TMC05	
Subtotal = 38	Subtotal = 26	Subtotal = 30	Subtotal = 23	Subtotal = 18	Subtotal = 06
Total interactions = 141					

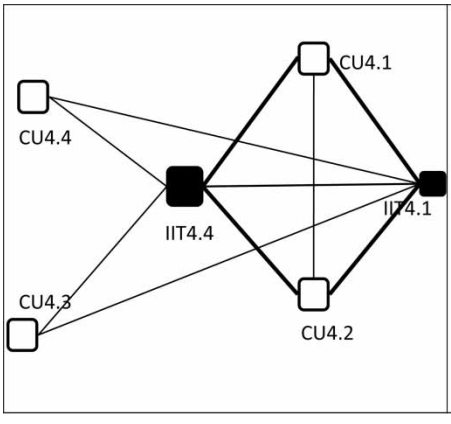
(Teams 3 and 4). We present this contrast in team performance by comparing the four teams in Table 11. We measure the final project quality as a parameter of task completion and individual/team satisfaction. This last parameter was measured through 'exit interviews' conducted with each of the teams at the end of the project.



Participants	C_D	C_B	C_C
CU4.1	1.000	1.000	0.400
CU4.2	0.750	0.845	0.200
CU4.3	0.625	0.733	0.200
CU4.4	0.625	0.733	0.200
IIT4.1	0.625	0.733	0.200
IIT4.2	0.625	0.733	0.256
IIT4.3	0.500	0.000	0.055
IIT4.4	0.500	0.000	0.055
IIT4.5	0.500	0.000	0.055
Network Degree Centrality = 0.4640			
Network Betweenness Centrality = 0.2120			
Network Closeness Centrality = 0.6117			



Participants	C_D	C_B	C_C
CU4.1	0.750	0.800	0.200
CU4.2	0.875	0.889	0.300
CU4.3	0.750	0.800	0.200
CU4.4	1.000	0.775	0.400
IIT4.1	0.750	0.800	0.200
IIT4.2	0.750	0.800	0.200
IIT4.3	0.500	0.000	0.145
IIT4.4	0.500	0.000	0.145
IIT4.5	0.500	0.000	0.145
Network Degree Centrality = 0.3035			
Network Betweenness Centrality = 0.2500			
Network Closeness Centrality = 0.7402			



Participants	C_D	C_B	C_C
CU4.1	0.875	0.889	0.300
CU4.2	0.875	0.889	0.300
CU4.3	0.625	0.714	0.200
CU4.4	0.625	0.714	0.200
IIT4.1	0.875	0.889	0.300
IIT4.2	-	-	-
IIT4.3	-	-	-
IIT4.4	1.000	1.000	0.500
IIT4.5	-	-	-
Network Degree Centrality = 0.1607			
Network Betweenness Centrality = 0.0500			
Network Closeness Centrality = 0.5571			

Figure 5 Sociogram/centrality measures: (a) technical interactions in February, (b) technical interactions in March, (c) technical interactions in April, (d) day 1 sociogram (reconstructed from DiMarco *et al.*, 2010) and (e) day 3 sociogram (reconstructed from Di Marco *et al.*, 2010)

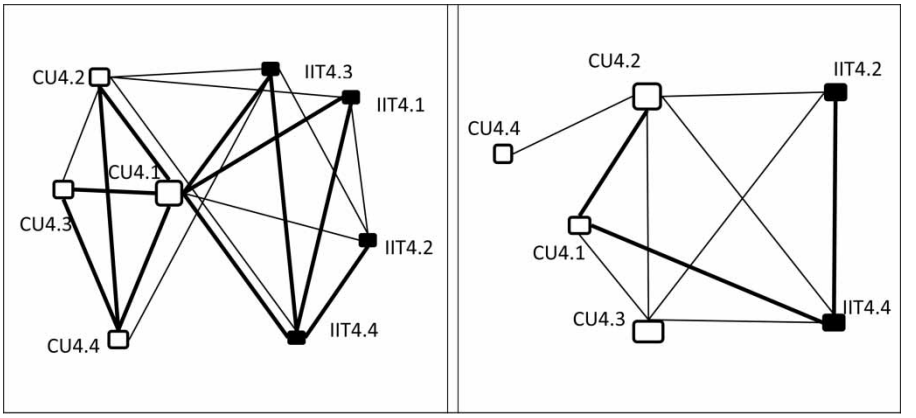


Figure 5 Continued

Enabling conditions and structural factors

There were several boundaries in our study, namely geographical, organizational, functional, technological and temporal. Based on the project, members were required to enact the following roles—GK/R's to *transfer* the data to build the base model, TBSs to *translate* these data such that the project could be optimized and CBSs to *resolve* the cross-cultural conflicts inherent in global projects and to facilitate the task process. Boundary spanners have the potential to mediate between distributed teams and project performance. Teams 1 and 4 appointed GK/R's to help transfer data but merely having this role was not sufficient for successful collaboration. In both these cases, the teams effectively functioned as two sub-teams with different scopes of work who did not work together iteratively or collaboratively. On the other hand, TBS's emerged in Team 2 and to a lesser extent in Team 3 and facilitated greater information sharing and collaboration. The competence of a CBS to impact effective team and project performance was evident in Team 2 alone. We thus contend that effective GK/R's, technical and CBSs are all required for project success and effective team performance. The enabling conditions vital for effective collaboration and the emergence of boundary spanners were identified to be group fraternization and richness in communication. The case-specific conditions in the teams and their end results indicate that the presence of enabling conditions alone does not always guarantee project success and high team performance. Team composition—the presence of potential boundary spanners characterized by attributes shared with members of both sub-teams for instance and other aspects of team dynamics act along with enabling conditions to impact effective team performance and successful project outcomes. We thus propose the following enabling/disabling conditions.

Case 1: Enabling condition: team fraternization

Two of the teams exhibited moderate to large levels of fraternization in the first month—Team 2 displayed 23 instances of group fraternization and Team 3 displayed 9 instances of fraternization in February. TBSs emerged in both these teams (albeit to a greater extent in Team 2 than in Team 3) and their overall networks were more dense and cohesive. This allows us to conclude that team fraternization in the formative months helps teams in socio-emotional bonding and creating an environment of shared understanding. This in turn enables the emergence of a TBS. Teams 1 and 4 showed no instance of fraternization, no TBSs emerged and both teams featured networks with low levels of density and therefore collaboration. It is not a surprise that the best performing team (Team 2) is present in the former group, whereas the worst performing team (Team 1) is present in the latter group. We thus state the following proposition.

> *Proposition 1*: Team fraternization in the initial stages of a project is an enabling condition that triggers the emergence of TBSs in practice.

Case 2: Enabling condition: richness in communication and members with shared attributes

Teams 2 and 4 experienced enhanced richness in communication through face-to-face interactions. We noted the emergence of a CBS (CU2.4 member with cross-cultural identity) in Team 2 during the face-to-face interaction. The emergent boundary spanner created a new field and pulled all the participants into it creating a harmonious and cohesive team (Levina and Vaast, 2005).

Team 4 on the other hand functioned as the combination of two fragmented sub-teams despite the richness

Table 11 Team comparison

Parameters	Team 1	Team 2	Team 3	Team 4
Conditions	Only virtual interaction Presence of CBS	Virtual and direct interactions Presence of CBS	Only virtual interaction Absence of CBS	Virtual and direct interactions Absence of CBS
Project outcome/ reason	Poor Task not completed	Excellent Team successfully completed the task and suggested optimizations	Satisfactory Managed to complete the basic task	Satisfactory Managed to complete the basic task
Participant satisfaction/reason	Not satisfactory Anger and disappointment	Highly satisfactory Cohesive and dense networks, harmony	Not satisfactory Anger, isolates, non-cohesive network	Not satisfactory Presence of isolates, non-cohesive network
Enabling conditions identified	—	Fraternization, richness in communication	Marginal fraternization, inclination of the participants, team spirit	Richness in communication
Structural factor identified	Presence of a potential boundary spanner with attributes shared between both sub-teams	Presence of a potential boundary spanner with attributes shared between both sub-teams	—	—
Disabling condition identified	One-to-one team interaction and leadership style	—	—	Absence of socio-emotional bonding and fraternization
Boundary spanners in practice	No emergence of boundary spanners	Emergence of TBS and CBS	Emergence of TBS	No emergence of boundary spanners
Final project quality	Highly ineffective team performance and failed project outcome	Highly effective team performance and successful project completion	Successful task completion but ineffective team performance	Successful task completion but ineffective team performance

in the communication environment. Merely enabling communication richness did not serve to bridge cultural or knowledge systems conflicts between sub-teams. The evidence indicates that enabling the richness in communication can become more effective in the presence of a potential boundary spanner with shared sub-team attributes such as CU2.4 in Team 2 (structural factor).

Team 1 in contrast had a member of Indian origin in the CU sub-team who did not play a boundary spanning role. We conclude that the lack of an enabling condition such as richness in communication may have hindered the process. This in practice is a disabling condition affecting project performance. We thus propose the following proposition.

Proposition 2: Team members with an inclination and the legitimacy to act as CBSs, who possess shared attributes across sub-teams emerge as CBSs in environments where communication richness is high.

This leads us to Proposition 2a which is a corollary of Proposition 2.

Proposition 2a: Increased richness in communication and the presence of members with shared attributes in the team are both necessary conditions for the cultural boundary spanning process to occur. The absence of either hinders the cultural boundary spanning process.

Case 3: Enabling conditions: presence of TBSs and CBSs in practice

This case combines cases 1 and 2. In phase 1 of the project, wherein all the four teams interacted only virtually, Teams 2 and 3 were the only teams that triggered the emergence of a TBS due to the group fraternization process. The emergent TBS in turn, spanned the technical boundaries more effectively than the GK and R's in Teams 1 and 4. This is evident from the quality of transfer of project specific information within the four teams at that stage. In phase 2 of the project, which is during the direct interaction, a CBS emerged in only one team (Team 2) due to the presence of a team member with attributes common to both sub-teams. The final project and team performance were based on the combined competencies of both the technical and the CBS. The emergent TBS and CBS for Team 2 resulted in high team performance and successful project completion. Thus, we propose the following.

Proposition 3a: The presence of TBSs alone leads to satisfactory project performance but ineffective team performance.
Proposition 3b: The combined emergence of both TBSs and CBSs in practice is a necessary condition that leads to high project performance and effective team performance.

With this understanding, we propose a theoretical framework as shown in Figure 6 that addresses our key research questions.

Accordingly, we suggest that there are two enabling conditions, team fraternization and communication richness, and one structural factor in team composition, the presence of a CBS, that impacts team performance. Fraternization leads to better performance of a TBS and communication richness leads to better CBS performance if one exists. The presence of both the enabling conditions and the presence of a potential boundary spanner with attributes common across project faultlines are vital for effective team performance and project success.

It is imperative to understand that not every member of the team can be enabled to span the cultural boundaries. Members with shared attributes across sub-teams are more likely to be triggered/enabled to perform this role by way of increasing the communication richness. Therefore, it is to be noted that increase in the communication richness alone does not necessarily lead to CBS emergence in practice. Communication richness along with individual(s) having shared attributes among sub-teams, means the team can trigger such team members to become a CBS in practice.

Concluding comments

This study has attempted to contribute both in terms of lending conceptual clarity to the fundamental issue of group dynamics in virtual teams and in demonstrating through empirical evidence the significance of enabling conditions and structural factors such as the role of fraternization, the emergence and role of various types of boundary spanners (technical and cultural) in resolving knowledge system conflicts and so on. Such enabling conditions and factors if identified early in a project, can lead to high performance teams and successful virtual collaborative project delivery. From a practitioners' point of view, it is strongly recommended that firms should invest in understanding and implementing such interventions. Firms may already be considering using nominated boundary spanners (Levina and Vaast, 2005) with shared attributes (DiMarco *et al.*, 2010) on global projects. However, it is imperative that these teams be encouraged to fraternize prior to executing their actual tasks and that the richness of communication be enhanced in order to enable these nominated boundary spanners to emerge as boundary spanners in practice and enable team performance.

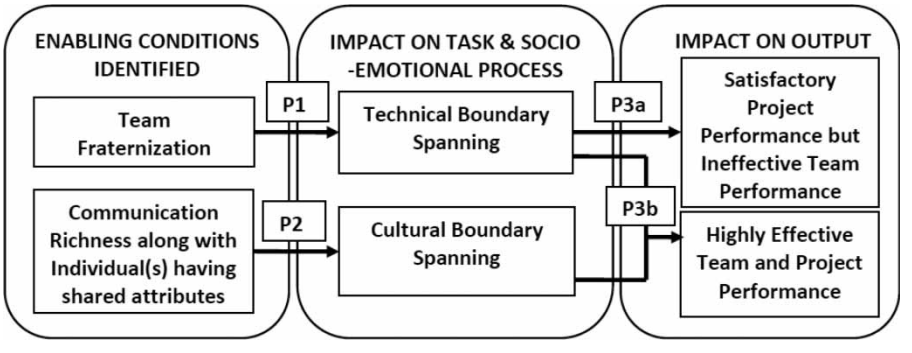


Figure 6 Proposed theoretical framework based on the propositions

This can be done in a variety of ways—by holding informal team building events, conducting technical workshops that would provide a common platform to build team cohesion, flying teams out to visit their team counterparts in other countries, investing in technology that fosters more effective collaboration and so on.

TBSs influenced team performance on task-related processes such as communication, coordination, task-technology fit, etc., while CBSs influenced relationship building, cohesion and trust formation in virtual teams thereby enfolding Powell *et al.*'s (2004) framework for virtual team interactions. However, we concede that other factors that we have not explicitly studied—such as inclination, legitimacy and effectiveness of the participants—could play a mediating role in the above equation by determining who plays the boundary spanning role, if at all, and so on. Although the study has focused on participant interplay and the importance of informal networks in organizations, the effect of individual personal capabilities that influence the establishment of enabling conditions cannot be totally ignored. Researchers suggest that virtual team members need to possess tolerance for ambiguity to deal with unstructured communication that characterizes much of virtual team work. They should also have the capacity to work with cross-cultural participants apart from the required task-related knowledge and skill (Gibson and Cohen, 2003; Andrews *et al.*, 2006). These are aspects that should be considered in future studies.

Our proposed theoretical framework presented is only a preliminary one based on early evidence and is expected to serve as a foundation that will be built upon and modified by future research. A major limitation in this study is that the exercise was conducted in a controlled environment with the participants motivated mainly by their grades rather than any monetary incentives which, in the real world, could lead to 'goal incongruence' impacting project performance. Furthermore, our sample sizes are small and do not lend themselves to easy generalizations. Also, our experiment was conducted only on global virtual teams. Some of our findings might apply to non-global or non-virtual teams as well and we require further studies on local virtual teams and traditional teams to understand the extent to which variables such as fraternization and richness in communication can impact project and team performances. Our methodology also raises interesting questions. For instance, would team performance have been different if face-to-face meetings had been carried out first? Our study is therefore intended to be exploratory and indicative and not comprehensive. The context of our research design adds several inbuilt limitations to the study. As the participants in our study came only from India and the USA, the cultural issues we observed may have been restricted to differences in cultural orientations between these two countries. Moreover, as we had only considered two sub-teams, our findings are limited to the analysis of bi-cultural and bi-organizational teams. Future research is needed to validate or modify our framework, and to understand the impact of personalities, cultures and organizations in real-world settings, as well as the role of technology in virtual teams. This can help enhance our understanding of designing and enabling virtual teams for improved project performance. Guidelines can then be formulated on how to design global teams so as to enable the emergence and effects of boundary spanning on real-world projects. Only then can we truly leverage the benefits that globalization brings to the AEC industry.

Acknowledgements

We thank Dr John Taylor for all the support rendered in coordinating and conducting this experimental research work between the two universities. We further thank him and his research team Melissa Di Marco and Kenny Wong for their timely insight during the data analysis phase of this research work, contribution in this field and valuable suggestions supporting this study.

Note

1. CU1.1 indicates member #1 in Team 1 from Columbia University. IITM3.2 would indicate member #2 in Team 3 from IIT-Madras. This notation is used throughout this paper.

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