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Beyond a Boundary: Towards a Dynamic Theory of Boundary Spanning in Global Virtual Teams

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INTRODUCTION

The Architectural, Engineering and Construction (AEC) industry is gradually undergoing a seismic shift in its organizational structure, with a major chunk of project delivery services being outsourced across the globe (Miles et al, 2004). Project teams are marked by a very high degree of heterogeneity, comprising team members from diverse backgrounds, ethnicities, cultures, etc. and working across temporal, spatial and organizational boundaries. As a result, Global virtual Teams (GVTs) have become an omni-present means of teamwork (Lipnack and Stamps, 1999). Communication across these very diverse teams is usually achieved through collaborative platforms, which range from elementary methods such as electronic mail to cutting-edge solutions such as live virtual meeting (Chinowsky 2003). Given the high degree of internal heterogeneity and external environmental uncertainty, boundaries emerge between sub-teams in the collaborative process. The methods of spanning these boundaries are of critical importance and are instrumental to fostering innovation in the GVT and facilitating performance of the team. This highly-researched field of Boundary Spanning Activities (BSA) has typically taken a static approach to intra-team social dynamics, notwithstanding a few recent forays into a more dynamic appreciation of the field (e.g: Levina and Vaast, 2006; Orlikowski, 2011). A static lens often assumes that boundaries and parameters surrounding boundaries (e.g. team heterogeneity boundary spanners, boundary spanning mechanisms, etc.) are fixed, while a dynamic perspective conceptualizes the evolution of boundary parameters as a function of context-specific variables such as project duration, nature of project tasks, team composition, etc. This study aims to unpack the dynamics of the BSA process, and provide fresh insights into the dynamic evolution of boundaries and spanning strategies over the course of work performed by GVTs.

THEORETICAL BACKGROUND AND RESEARCH FRAMEWORK.

Global Virtual Teams are typically composed of smaller sub-teams distributed across a range of geographical locations and separated across time zones. These sub-teams have specific knowledge domains and expertise relating to specific sub-tasks and are required to collaborate and create new knowledge during the course of the project. GVTs typically include highly heterogeneous knowledge distribution amongst the sub-team (Tiwana and Alavi, 2002; Lojeski, Dominick and Reilly, 2007), and knowledge sharing is to be achieved by various team collaboration processes. Further, the process of sharing “knowledge” embodied in the intra-team practices and the team members themselves is often cumbersome, and the organizational hierarchy has to be flexible enough to ensure efficient

throughput. This process is critical for making the collaboration effective, the lack of which hinders innovation and efficient knowledge management on the projects (Adenfelt,2009; Jarvenpaa, Knoll & Leidner, 1998;Espinosa & Carmel, 2003, 2004; Espinosa et al., 2003; Earley & Christopher, 1993; Hiltz,Coppola, Rotter, & Turoff, 2000; Jarvenpaa & Leidner, 1999). The “pockets” of knowledge created within the team lead to boundaries in these, and require the institution of a boundary spanning process (Malhotra et al, 2007; Gibson and Cohen,2003; Trautsch, 2003).

The field of boundary spanning activities is a highly studied one, with over 3 decades of research investigations. Early research work in the field focussed on establishing the importance of boundary spanning. Aldrich (1977) used a boundary theory perspective to establish that organizations (such as the GVT) depend on their external environment to obtain critical resource inputs and to dispose of outputs. Leifer (1977) established that the phenomenon of boundary spanning mediates between perceived environmental uncertainty and the organizational structure. The study underlined that this process is critical to keeping the team abreast of external changes, and thus maintains flexibility on the part of the team to obtain project deliverables. Tushman(1978) further built upon this understanding to argue that boundary spanning caters to informational requirements of the team, and helps manage the informational boundaries for the team. This macro-level understanding of the boundary spanning process underlines its importance in knowledge management systems, and its imperativeness in the working of GVTs.

A study by Jemison (1984) developed a demarcation of the categories of boundary spanning activities. The study discussed the roles involved in boundary spanning as encompassing three types, namely- Information acquisition, Domain Definition and Physical Input Control, thus defining the inter-play of phases of the process. This line of enquiry was further unpacked in a study by Ancona and Caldwell (1990). Their seminal work focussed on understanding X-teams for improving innovation and performance on projects and described boundary spanning activities as consisting of different steady-state functions of an ambassadorial, task-coordination and/or scouting variety. This ground-breaking work helped understand and characterize the aspects of spanning behaviour exhibited as a team-level phenomenon, and thus built an appreciation for the functions that effective boundary spanners should undertake for success in the project. The same authors further argued that mere standalone ambassadorial activities are largely ineffective, and need strong coupling with task coordination. The work by Podolny et al (1992) lent greater clarity to the field, with an investigation of differentiated boundary spanning functions such as including gatekeepers, representatives, socio-emotional tie-brokers and task-oriented tie-brokers. This study helped conceptualize the different kinds of boundary-spanning roles that could lead to effective performance.

Boundaries themselves have been extensively studied and characterized over the years. Boundaries have been classified into Technological (Maznevski and Chudoca, 2000), Cultural

(Sosik and Jung; 2002), Temporal (Espinosa and Carmel, 2004), Geographic (O’Leary and Cumming, 2002), Organizational (Pearce et al, 2003) and Functional types (Grinter, Herbsleb and Perry (1999). Carlile (’02), in his study on Transferring, translating, and transforming: An integrative framework for managing knowledge across boundaries, categorized boundaries from a knowledge transfer perspective. This research study contributed the perspective of syntactic, semantic and pragmatic boundary classifications and characterized knowledge movement as a function of increasing novelty at the boundary. Syntactic boundaries are those requiring mere transfer of existing knowledge, semantic boundaries are ones requiring translation of existing knowledge, whereas pragmatic boundaries require the transformation of existing knowledge into new knowledge. This study thus highlighted the cause-effect relationship between boundary characteristics and the intrinsic team environments.

Recent work in the field has focussed extensively on the boundary spanning process and the antecedents to the phenomenon. A study by Weedman (1991) suggested that the Boundary Spanning process required the institution of informal channels of communication, and the flexibility of these channels are critical to successful spanning. Manev and Stevenson (2001) established that spanning behaviour on the part of the individuals of the team is strongly related to influence irrespective of hierarchy, thus highlighting the relationship between boundary spanning and social capital. Golden and Veiga (2005) identified the cultural antecedents to this process, arguing that intrinsic cultural tendencies of the team strongly influences the nature of the spanning process. The flexibility requirement of the spanning process was highlighted in a study by Gary Noble (2006), which established that the spanners on the team experience continuously changing environments and scenarios. This study underlined the flexible and dynamic nature of the spanning process. Marrone (2007), in her study titled “A multi-level investigation of antecedents and consequences of team member boundary spanning behaviour”, established that both team-level and individual characteristics are critical to the boundary spanning process. This study bridged the gap between the team and member level antecedents of the process, and underlined the importance of intrinsic parameters such as emotional intelligence and heterogeneity in teams.

Recently a “practice-theory” approach (Bordieu, 1977, 1990; Ortner, 1989) towards understanding and delineating organizational structures has brought in a contemporary sociological perspective to extend theoretical frameworks and relationships to understand the boundary spanning process. Levina and Vaast (2006), for instance, described the dynamics of boundary spanning process. Using the concepts of ‘boundary spanners-in-practice’ and ‘boundary objects-in-use’, this research effort presented a process-centric approach to boundary spanning, and refuted the notion of the boundary spanning process being a static, isolated phenomenon. These notions of boundary spanners “in-practice” underlined the importance of the dynamic nature of the social mechanisms involved in

collaboration and the bridging of the various technical, cultural and other boundaries. Recent work on practice theory by Orlikowski et al (2011) established the pre-eminence of context-specific process dynamics, providing fresh insights into the cause-effect relationships of social practices and establishing their dynamic behaviour. The four-pronged approach- the “what”, “why”, “when” and “how” of practices and their corresponding contexts highlighted the intricate dynamics involved in all social collaboration practices and mechanisms, and are of immense importance in developing a dynamic theory of boundary spanning in GVTs.

Despite these recent advances where boundary spanning activities are seen as dynamic and context-based, the notion of boundaries remains conceptualized as a static construct. A large majority of the extant literature fails to consider variations in boundaries over time and consequent impact of these dynamics on boundary spanning strategies and practices. On the other hand, observations on GVT's indicate that as projects progress, there is an inevitable shift in the kinds of activities undertaken by teams and the personnel involved, thereby implying that there might be shifts in the location and nature of boundaries as well. This paper takes a first step in this direction, and focuses on understanding the evolution of boundaries and the spanning process as a global virtual project progresses. Investigating the practices involved in these phenomena, this study aims to unpack the *boundary evolution and spanning process* and thus develop a robust and dynamic theoretical perspective of boundary spanning in GVTs.

RESEARCH SETTING

In order to investigate the dynamics resulting from boundary evolution, we observed collaboration exercises of graduate students from four geographically-dispersed universities- IIT Madras (IITM), University of Twente (UT), University of Washington (UW) and Virginia Tech (VT), working together on a joint project. This exercise was a part of the graduate curriculum taught at various universities. Two collaboration platforms were used- CyberGrid (a platform used only for academic purposes, but with the ability to enable rich communication through the creation and movement of virtual ‘avatars’) and SOCOCO (used extensively in commercial applications, containing the ability to communicate data, share screens and so on, but without the facility to transmit social cues through the use of ‘avatars’ as in the case of CyberGrid). The participants were divided into 6 teams - 3 working on each of the two platforms. Each team had 9-members and comprised of 3-students from IITM, 3 from UT, 2 from VT and 1 from UW. The IITM team members were unable to log in to the CyberGrid sessions owing to technical problems, and connected remotely through Instant Messaging software, while their other teammates worked collaborated on the CyberGrid. No such technical issues arose on the SOCOCO teams. The teams had to sequentially execute a series of tasks involving digitally modelling the addition of three rooms to an existing building, developing Cost Estimates, Building Schedules and 4D simulations. The teams met for ten weekly sessions over two and a half months, with each

session lasting around two hours. The tasks were distributed among the university-level sub-teams uniformly, with IIT being tasked with leading the development of the 3D model using Revit Architecture, UT with leading the preparation of Cost Estimates, VT with leading the creation of Building Schedules using SimVision and UW with leading the preparation of 4D simulations using Navisworks. Each of these teams had specific expertise in the area of the task assigned to them. In addition, all the teams had knowledge of and access to Revit Architecture required for the 3D model, the University of Twente had sole knowledge of the cost estimation procedure used, University of Washington and IITM had expertise in Navisworks and Virginia Tech had sole knowledge of SimVision. Giving the varying nature of tasks and expertise over the lifecycle of the project, we expected the boundaries to evolve and vary as well, making this an ideal setting to investigate our research objectives.

RESEARCH METHOD

A qualitative methodology was used in analysing the episodes of boundary spanning encountered in the collaboration sessions. The individual sessions of each team (approximately 2 hours each), spread across 9 meetings were recorded in video form. The sessions were then parsed through and episodes of boundary discovery, initiation and spanning were documented. A grounded theory approach was used for investigation, where the episodes obtained from the sessions were coded and analyzed. The episodes were first coded based on whether they demonstrated instances of syntactic, semantic or pragmatic boundaries, following Carlile's (2002) framework. These codes were then grouped together to track underlying patterns permeating the data-space of episodes of boundary evolution, initiation and resolution. Finally, building on the findings from these patterns, we propose hypotheses explaining the findings, and thus develop a dynamic theory of boundary evolution and spanning.

KEY FINDINGS AND OBSERVATIONS

Evolution of boundaries over the project's duration.

The analysis of the boundary episodes in the team's collaboration meetings showed significant evolution of boundary characteristics across the project duration, and presented interesting trends in response to the variance of the timeline and the knowledge domains traversed. In the process of analysis, the boundary episodes were characterized into two broad categories - team and task coordination boundaries, which are first explained below.

Team Coordination boundaries: - These are boundaries relating to the team's decision making process that facilitate the tasks of the project, and do not include activities that are internal to the project's core-work environment. An example is the decision making process of coordinating meeting schedules, which when accomplished facilitates the project's tasks to be accomplished. Excerpts of a conversation involved in a *team coordination boundary* are presented below.

VT2- Hey , I was wondering, you know, how should we sequence the presentations amongst ourselves?

UW- Well, maybe we should present the work, in the sequence that we have worked here.

IIT3- That would be great. We can start off, with our work on the Revit Model, and then the guys at UT can continue. Does that sound okay?

UT-3. Yep, that sounds great. We can talk about the cost estimates after IIT is done, and then Virginia Tech can come in, and (UW) can finish off with his 4D simulation model.

As the conversation suggests, the *Team Coordination Boundaries* emerge from the gaps in understanding encountered as team members try to coordinate the team environment. Across the duration of the project, episodes relating to team coordination boundaries evolve significantly, both in terms of instances (counts) of boundary episodes, as well as the nature of these episodes. The instances of such boundaries are found to be correlated to the external imposition of organizational constraints (deadlines, deliverables, etc.), and are in conformation with the findings by Joshi et al (2009). Over time, richer and denser communication patterns evolved within project teams as these boundaries were treated. Teams moved from highly constrained networks to much more egalitarian, across-the-board collaboration networks. This dynamic is illustrated by the social network diagrams shown in Figure 1 below representing instances of team coordination boundary emergence and treatment over the course of the project for one of the teams. The social network diagrams essentially map the frequency of communication between members on a project team during a particular interaction session.

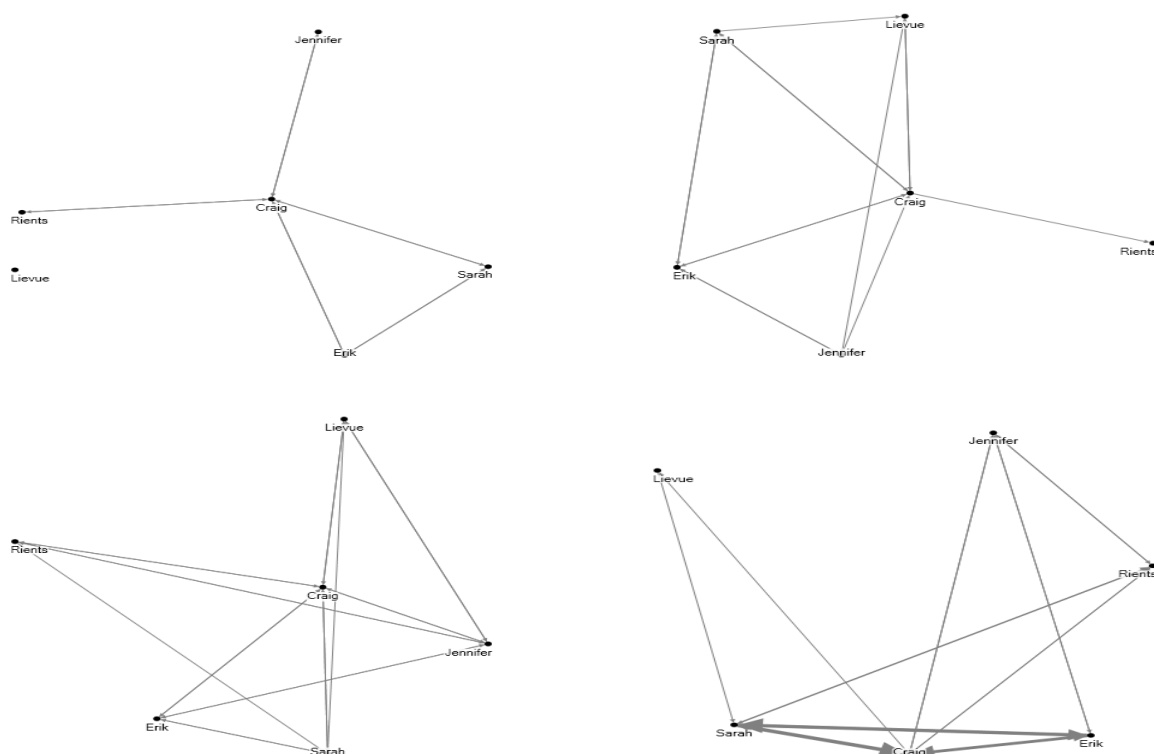


Figure: 1- Team Coordination Boundary SNDs, from left clockwise- Session 2, Session 5, Session 7 and Session 10. (Team-CyberGrid Team 1).

Table: 1 -Group Metrics for SND #1 (Session 2)

Member	Closeness Centrality	CC Variance	Eigenvector Centrality	EC Variance
Jennifer	0.143	-0.024	0.128	-0.039
Craig	0.380	0.213	0.299	0.132
Erik	0.167	0.000	0.223	0.056
Sarah	0.167	0.000	0.223	0.056
Rients	0.143	-0.024	0.128	-0.039
Lievue	0.000	-0.167	0.000	-0.167

Table: 2 -Group Metrics for SND#2(Session 5)

Member	Closeness Centrality	CC Variance	Eigenvector Centrality	EC Variance
Jennifer	0.143	-0.024	0.175	0.008
Craig	0.260	0.093	0.175	0.008
Erik	0.143	-0.024	0.175	0.008
Sarah	0.200	0.033	0.231	0.064
Rients	0.143	-0.024	0.175	0.008
Lievue	0.111	-0.056	0.070	-0.097

Table: 3 -Group Metrics for SND #7

Member	Closeness Centrality	CC Variance	Eigenvector Centrality	EC Variance
Jennifer	0.143	-0.024	0.148	-0.019
Craig	0.237	0.070	0.210	0.043
Erik	0.167	0.000	0.173	0.006
Sarah	0.167	0.000	0.173	0.006
Rients	0.143	-0.024	0.148	-0.019
Lievue	0.143	-0.024	0.148	-0.019

Table: 4-Group Metrics for SND #10.

Member	Closeness Centrality	CC Variance	Eigenvector Centrality	EC Variance
Jennifer	0.143	-0.024	0.148	-0.019
Craig	0.177	0.010	0.173	0.006
Erik	0.173	0.006	0.173	0.006
Sarah	0.173	0.006	0.173	0.006
Rients	0.167	0.000	0.167	0.000
Lievue	0.167	0.000	0.167	0.000

The Social Network Diagrams show that the team communication density increases as the project progresses, in the form of increasing edge weights in the network, signifying greater number of messages per communication instance. Further, Figure 2 to Figure 5 show tapering of the EC and CC Variance for the team members as the project progresses, underlying the fact that the communication networks become more egalitarian.

Thus, based on the findings above, we draw the following proposition:-

Proposition 1: Social capital is accumulated over the progress of the project. As a result, the treatment of Team Coordination Boundaries is characterized by denser and more egalitarian networks as the project progresses.

Task Coordination boundaries: - These refer to boundaries that are created as team members take decisions to accomplish project tasks. These encompass activities such as work discussions, technical query resolutions, etc. Task coordination boundaries are typically found to manifest in the form of gaps in knowledge and understanding between team members. An instance of a conversation revolving around a *task coordination boundary* is presented below.

IIT3- Hey guys. I had a question. Is the building currently in use?

UW- Oh. Good question. I don't know.

VT-2- Well, I guess it could be operational. But, then we shall have to consider shutting down the building, for the new extension.

VT-1. That is true. But, we were told to assume all that we need, and I think taking the building as operational would add a lot of extra tasks.

In our study, the task coordination boundary episodes show a high extent of variance in response to the distribution of knowledge domains among the sub-teams in the GVT. In Phase 1 of the project (3D modelling using Revit Architecture), technical expertise on Revit and 3D modelling was uniformly distributed across all the four sub-teams. This phase of uniform expertise distribution featured a frequent occurrence of pragmatic boundaries (as a percentage of total boundaries). Take the following interaction observed on one of the teams, for instance, during the 3D Revit modelling phase of the project:

UT1.- Hey, I had an idea. We have not really looked at possible roof solutions for this model, have we?

VT1. –Well, not really. But I guess we could consider something like a compound ceiling .

VT2. That's actually a nice idea. How about water-harvesting systems placed in place? Since we have decided that the building is based in Netherlands, I guess the rainfall would be substantial.

UW:- Yeah, that would be really interesting. So, how about we install such roofs for the new rooms? Maybe we could explore the possibilities in the model in the CyberGrid..

UT1:- Yeah. I was just seeing the model. These roofs for the new rooms to be added would work great. Also, we need not demolish existing roofs for these, and just keep them in the new rooms.

UT1:-Nice. That's great. Do we all agree to this?

UW: I am on board. I think we should send this across to IIT.

VT2: Yes, I agree as well.

Participant's familiarity with the tool allowed them to discuss on an 'even footing' leading to creative suggestions and the transformation of the knowledge embedded in the original model.

This is in stark comparison to the low counts of pragmatic boundaries encountered in the phases involving work on Cost Estimation, Navisworks schedule and Simvision 4D simulations. These phases, with lop-sided technical expertise distributions, witnessed predominantly syntactic and semantic boundaries being encountered, with the sub-teams primarily adopting a "black-box" sort of approach.

UT2:- Hey, now that we have the project duration and start and end dates , we should, have them in the Navisworks files and simulation models as well.

UT1. Yeah. Maybe VT and UW2 can do that I mean, I do not really know how the Simulation is made from the Navisworks file.

VT-1.- Yes. With these start and end dates, we can put them into the Navisworks, and then, the csv file goes into the 4D simulation, I think.

UW- Yes that should work fine for me I think. Maybe Virginia Tech can create the schedule using the dates (pause), and I can then produce the SimVision model.

VT-2. Yep. That would be great. We shall start working on the schedule, then.

In this conversation, information on the tool had to be transmitted and subsequently clarified in order for the group members to carry out their tasks to complete the project. Tables 5 to 8 present some instances of boundaries from different phases of the project. These episodes are those encountered in the collaboration sessions of CyberGrid Team 3.

Table:-5-Boundary episodes in 3D modelling phase.

Task Involved	Boundary Classification	Boundary Type
Fixing walkway, terrace, roof ceilings.	Task Coordination	Pragmatic
Query about glitches in model	Task Coordination	Syntactic
How to model the roof and slabs.	Task Coordination	Pragmatic
How to install the walkway to the roof	Task Coordination	Pragmatic

Table: 6 -Boundary Episodes in Cost-Estimate phase

Task Involved	Boundary Classification	Boundary Type
Modification of model	Task Coordination	Pragmatic
Empty space allocated in model	Task Coordination	Semantic
How to fix glitches in model	Task Coordination	Pragmatic
What to put in report	Task Coordination	Semantic
How to coordinate documents	Task Coordination	Pragmatic
What to do about a missing wall	Task Coordination	Pragmatic
Start writing stuff in the report	Task Coordination	Syntactic
What goes into cost estimat	Task Coordination	Syntactic

Table: 7 -Boundary Episodes in Scheduling phase

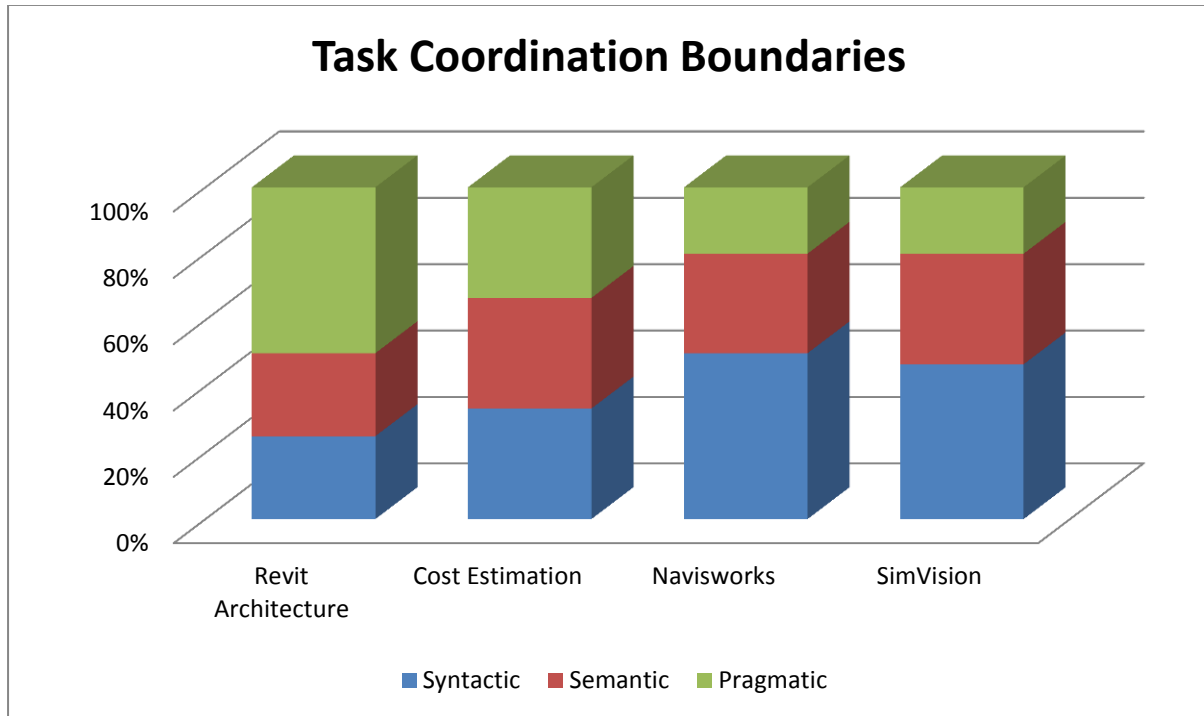
Task Involved	Boundary Classificatic	Boundary Type
What does roof staircase mean	Task Coordination	Syntactic
How to import csv files into Navisworks	Task Coordination	Semantic
Change model/change schedule	Task Coordination	Pragmatic
How to change exisiting roof materials	Task Coordination	Pragmatic
What were the durations based out of/	Task Coordination	Semantic
Cost of column?	Task Coordination	Semantic
Hand rail queries	Task Coordination	Semantic
Pre-fab elements	Task Coordination	Pragmatic
How to coordinate schedule and cost estimates	Task Coordination	Pragmatic

Table: 8 -Boundary episodes in 4D simulation phase

Task Involved	Boundary Classification	Boundary Type
Labelling of walls in 4d simulation	Task Coordination	Syntactic
Glitches/issues in the 4D simulation	Task Coordination	Semantic
Coordinate Navisworks and Simvision	Task Coordination	Pragmatic
Discussion about changing materials and methods	Task Coordination	Pragmatic

These episodes underline that the distribution of technical capital amongst the sub-teams is instrumental in deciding the incidences of syntactic, semantic and pragmatic boundaries. In the initial stages, all the 4 sub-teams worked in Revit, software that was common knowledge to all involved. However, as the teams progressed to stages wherein the knowledge of the tools was limited, the sub-teams operated in a “black-box” mode; with the teams without expertise merely getting their queries clarified, thus leading to instances of syntactic and semantic boundary transactions only. The trend of instances of syntactic, semantic and pragmatic boundaries depicts a similar picture, as presented in Figure 2 below.

Figure: 2-Instances of Task Coordination boundaries for SOCOCO Team 1.



Thus, there is a clear shift towards more semantic and syntactic boundary episodes and lesser pragmatic boundary instances as tasks become more specialized and as expertise is distributed. Based on the findings above, two propositions can be drawn:

Proposition 2: Uniformly distributed technical expertise (capital) leads to higher pragmatic boundaries being encountered among the sub-teams.

Proposition 3: Lop-sided technical capital distributions lead to predominantly syntactic and semantic boundaries.

Boundary Initiation Methods.

The process of boundary initiation is hitherto unexamined, and in our study we have taken a step in this direction by noting the major social patterns that lead to the activation of a discovered boundary in a boundary episode. In this context, the “initiation” method is defined to be the social communication mechanism preceding the identification of a boundary, and its consequent spanning effort. By coding these communication mechanisms preceding each boundary episode, we found two main categories of boundary initiation methodologies amongst the 6 GVTs studied. The two categories are described below.

Query Method

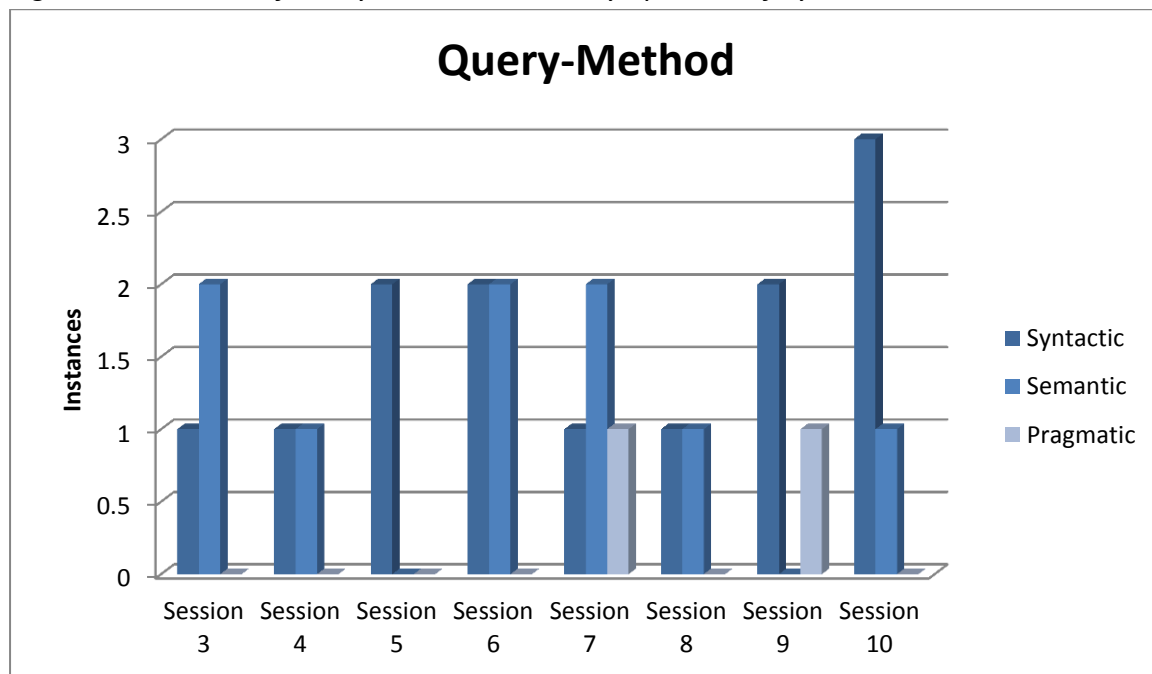
This “practice” of initiation involves questions being asked by members of the teams amongst each other. The boundary is thus “activated”, by the question-answering process. This method of initiation is usually a low-attention activity and merely seeks information to

bridge a gap. The following statement from a VT team member illustrates this method:

VT2:- Hey, (UW), I had a question. Does the Simvision model show both the old and new elements in the constructed model separately?

The *Query Method* of initiation was found to be used typically for syntactic and semantic boundary episodes. Ranging from simple knowledge gaps to more specific and contextual understanding gaps, this method was found to be extensively used throughout the projects. These findings lead to the conclusion that this method is employed for low-to-mid novelty boundary episodes and are prevalent throughout the project duration, used predominantly for syntactic and semantic boundary episodes. Figure 3 depicts instances of this method of initiation is presented, across all the sessions for one of the GVTs.

Figure: 3-Instances of Query-initiated boundary episodes of CyberGrid Team-3.



We thus posit the following proposition:

Proposition 4: Query-method is often used to initiate syntactic and semantic boundaries at low-to-mid novelty environments.

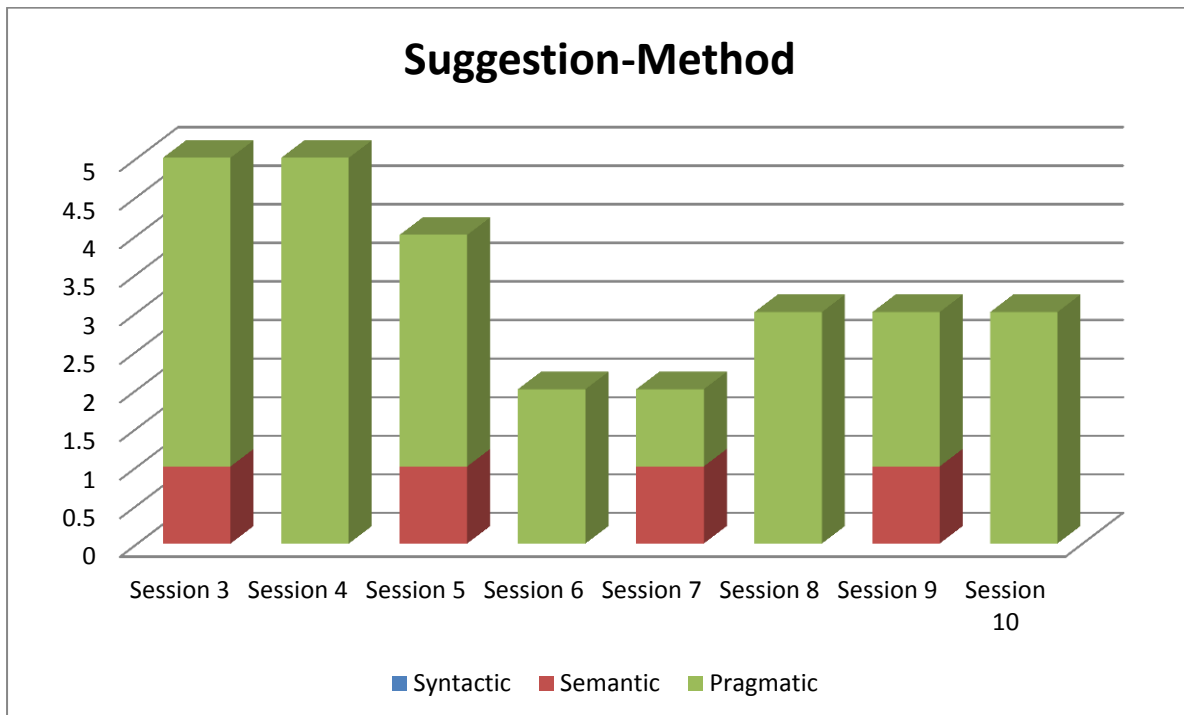
Suggestion Method

This method of initiation involves an assertion by a sub-team member soliciting the attention of the entire GVT to a particular boundary, thus activating the boundary. This method is one requiring a high degree of social capital. An instance of this method of initiation is given below.

VT2: Hey, I was thinking, that maybe, we could have a rehearsal for the final presentation. But, we shall need to coordinate the sequence in which we present.

This instance led to the activation of a boundary involving a role definition gap and is an example of the suggestion methodology used for boundary initiation. This method was found to be used for semantic and pragmatic boundary episodes, and thus catered to mid-to-high novelty environments. Tables presenting instances of suggestion-initiated boundary instances are presented below. The distribution of *Suggestion-Method* initiated boundary episodes for one of the GVTs is presented in Figure 4 below.

Figure: 4- Instances of Suggestion-initiated boundary episodes of CyberGrid Team-3.



From the above findings, we present the following proposition:

Proposition 5: Query-method is often used to initiate pragmatic and semantic boundaries at mid-to-high novelty environments.

Boundary Treatment Practices.

Post our study of boundary initiation, our next step is to take a microscopic look at the social practices that are involved in the treatment of these boundaries. These “practices” involve the communication patterns that are encountered at the interface of the boundary in the GVT. For each of the boundary episodes, the combination of practices involved in the treatment process was analysed. We observed 5 practices that recurred across teams and projects. These practices are termed Information Dissemination, Information Input, Opinion Input, Discussion, Consensus and Explanation. A few excerpts of boundary episodes and their treatment are presented below, which help outline the broad range of practices that were found to be involved in the treatment process. These episodes are characterized into

syntactic, semantic and pragmatic boundaries, and the patterns in practices involved are examined.

The 'Information Dissemination' practice is illustrated in the following episode:

IIT1- Does the cost estimate reflect the status of the crane during the phases?

UT2- Yes, it does. For each phase, the costs have been calculated differently as per the mobile or idle status.

In the above instance we have a syntactic boundary episode involving a knowledge gap. The boundary is initiated using the *Query Method*, and is addressed by the UT member. The message from UT2 to IIT3 involves a simple one-to-one correspondence across the boundary involving transmission of existing information. Such a practice is characterized as *Information Dissemination*.

'Information Input', 'Explanation' and 'Discussion' practices are illustrated through the episode below:

IIT1- (UW), I had a question. What is a patio?

UW- Well, it is an outside balcony of sorts. You could go out there to have a cup of coffee maybe, or to smoke, you know.

UT: Yes. Like the ones you have in most office buildings. You can see them in high-rise buildings that you see in TV series.

IIT1- So, it is just towards the end of a floor? Like, jutting outwards?

UW- Yes, something like that. We could place it at any end on the floor.

IIT1:- That sounds good. I think we could add that.

As this episode shows, practices are often present in combination with one another during a boundary treatment episode. The above instance is that of a semantic boundary episode involving a knowledge gap. The first statement by UW involves context-specific information being submitted into the GVT collaboration space. This practice is classified as *Information Input*.

The statement by UT involves one-to-one flow of processed information from one side of the boundary to the other, but with a greater degree of clarification and tailored to the requirement of the receiver. This practice is characterized as *Explanation*.

The second statement by UW and the last two statements are to-and-fro interactions, which are classified as the *Discussion* practice.

'Opinion' Input' and Consensus' practices are explained through the following episode:

IIT3- Hey guys. I had a question. Is the building currently, in use?

UW- Oh. Good question I don't know.

VT-2- Well, I guess it could be operational. But, then we shall have to consider

shutting down the building, for the new extension.

VT-1. That is true. But, we were told to assume all that we need, and I think taking the building as operational would add a lot of extra tasks.

UT-3. Yes, but I think it would be better to assume it that way. Because, you would not generally see a building just lying around, you know.

IIT3: I think that's a fair point. Maybe we should consider the building as operational.

VT-1: Well, yes, considering that, maybe we should.

UW: - So, do we all agree to take the building as an operational one?

UT3:- Yes, we do.

IIT3: Yes.

This instance is that of a pragmatic boundary episode involving an understanding gap. The statement by VT-2 and the first half of the first statement by VT-1 is another instance of *Information Input*. The first statements by VT-1 and UW are to-and-fro interactions between the sub-teams of the GVT, with frequent trading of information and opinions. This is classified as the *Discussion* practice.

The last three statements lead to a stage of mutual agreement amongst all the members of the GVT on a particular topic, and is characterized as the *Consensus* practice.

The second statements by IIT3 and UT3 are submission of context-specific opinion being submitted into the GVT collaboration space, and are characterized as the *Opinion input*.

Based on these at-the-boundary practices that emerged as being involved in boundary treatment, we coded the combinations of practices observed for each boundary episode. In our study of the collaboration sessions of the 6 GVTs, the teams were found to employ various combinations of the above practices. For each of the boundary types (syntactic, semantic and pragmatic), the combinations of interaction practices that occurred most frequently are given below-

- a. Syntactic Boundaries- In this low-novelty zone, typically the practice of *Information Dissemination* is found to be used as a spanning mechanism, generally in a stand-alone manner.
- b. Semantic Boundaries- The mid-novelty zone boundary episodes witnessed spanning achieved by a combination of *Information input*, *Discussion* and *Explanation*.
- c. Pragmatic Boundaries- The high-novelty boundaries were spanned by a combination of *Information Input*, *Opinion Input*, *Discussion* and *Consensus*.

As an illustration, Table 9 below represents the boundary treatment practices for boundaries that evolved during one of the interaction sessions for SOCOCO Team 1.

Table:-9-Instances of Boundary Episodes and Treatment- Navisworks Session.

Task Involved	Boundary Type	Boundary Treatment Method					
		Information Dissemination	Information Input	Opinion Input	Explanation	Discussion	Consensus
What does roof staircase mean	Syntactic	✓					
How to import csv files into Navisworks	Semantic		✓		✓	✓	
Change model/change schedule	Pragmatic		✓	✓		✓	✓
How to change existing roof materials	Pragmatic		✓	✓		✓	✓
What were the durations based out of/	Semantic		✓		✓	✓	
Cost of column?	Semantic		✓		✓	✓	
Hand rail queries	Semantic		✓		✓	✓	
Pre-fab elements	Pragmatic		✓	✓		✓	✓
How to coordinate schedule and cost estimates	Pragmatic		✓	✓		✓	✓

DISCUSSION AND CONCLUSION

This study attempts to develop a dynamic theory of boundary spanning in of the context of Global Virtual Teams. The findings from the study underline the importance of developing a more practice and process-oriented understanding of project dynamics. Boundaries trace distinct patterns of evolution over time, and the internal and external project environments in combination are instrumental in shaping these patterns. Development of social capital and the extent of knowledge distribution on tasks are some of the factors that determine the kinds of boundaries that will evolve as a project progresses. From a practical perspective, managers of GVTs may be able to use some of these findings to predict the occurrence and type of boundaries over the course of the project. Furthermore, the boundary treatment practices offer insights as to the kinds of practices that organizations can foster ex-ante in order to ensure successful boundary spanning ex-post. Boundary spanning can therefore be dealt with systematically, rather than leaving this to the inherent 'skills' of boundary spanners.

However, several practical and theoretical questions remain unanswered. Replication of this study across different teams and different environments, going beyond student-experiments can serve to validate or re-phrase our propositions. Our study indicates that there needs to be a closer link between studies on boundary spanning in GVTs and studies of team-level trust, particularly if trust between team-members is effective in spanning non-technical or team-coordination boundaries. Our observations indicate that such trust is built over time. Yet, it is important to explore the circumstances under which this may happen, and circumstances under which team trust might be fragile and may need to be repaired.

Boundary initiation is also an area that remains largely unexplored. Theory here can be further developed by examining correlations between boundary characteristic, the initiation method psychometric parameters of actors in a team (such as Emotional Intelligence and so on). Understanding at-the-boundary practices that constitute spanning mechanisms provides far-reaching consequences for academics as well as real-life practitioners. Boundaries appear to be far more dynamic than hitherto conceptualized in the extant literature. Our observations show considerable variety and variation in boundary type and occurrence over the lifecycle of a project. Embracing such a perspective can allow

researchers to further unpack the dynamics of project activities in global teams. It is therefore time to move beyond a boundary.

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