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EXPLORING THE ROLE OF CULTURAL BOUNDARY SPANNERS AT COMPLEX BOUNDARIES IN GLOBAL VIRTUAL AEC NETWORKS

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SUMMARY: *As the architecture, engineering and construction industry continues to globalize, project work is more often executed by geographically distributed, technologically mediated teams of knowledge specialists organized into global virtual project networks. These networks are characterized by a number of boundaries that must be spanned in order to develop effective project outcomes. Prior research has examined the efficacy of cultural boundary spanners and technical boundary spanners in these types of networks, but we lack an understanding of how spanners perform in complex boundary environments where boundaries co-occur. Our research aims to explore the efficacy of cultural boundary spanners who are positioned at technical and knowledge domain boundaries. The results of our preliminary research suggest that cultural boundary spanners may only be effective at facilitating efficient information transfer when they are positioned at a knowledge domain boundary in which they have specialization. We found that the interactional norms that develop within the network based on the efficacy of boundary spanners can also position them at inappropriate knowledge domain boundaries, which can lead to decreased efficiency of information transfer. Our research provides an initial contribution to our understanding of boundary complexity in global virtual projects networks with implications for improving network performance.*

KEYWORDS: *boundary spanning, complex boundary environments, global, networks, project networks, virtual team.*

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1. INTRODUCTION

Project-based industries such as Architecture, Engineering and Construction (AEC) are globalizing (Messner 2008, Colella et al. 2012). In AEC, design and planning work is often internationally outsourced because large-scale, complex projects require specialized knowledge that may reside in offshore firms. By leveraging advances in information and communication technologies (ICTs), designers, planners, and managers can remain in situ, thus increasing profits and reducing costs. However, these types of Global Virtual Project Networks (GVPNs) are challenging work environments (Chinowsky and Rojas 2003) because cultural and technical boundaries can interfere with effective collaboration (Ramalingam and Mahalingam 2011). Because of project complexity, knowledge domain boundaries often co-exist with cultural and technical boundaries. This *boundary complexity* (Espinosa et al. 2014) must be addressed for effective work practices to emerge in GVPNs.

Research on how boundaries impact collaboration in GVPNs is typically limited to studies of individual boundaries in isolation, including technical (Hinds and Bailey 2003), cultural (DiMarco et al. 2010, DiMarco et al. 2011) and knowledge domain boundaries (Gopal and Gosain 2010). Because boundaries studied in isolation do not necessarily reflect the organizational context in which they are situated, the results from these studies and others are often challenging to translate into practice. From this research tradition, strategies have emerged that focus on the role of human (Levina and Vaast 2005) or technological (Iorio et al. 2014) interventions that help GVPNs to span boundaries. These *boundary spanners* can help to improve information and knowledge transfer across boundaries (Friedman and Podolny 1992). However, with few exceptions (Ramalingam and Mahalingam 2011), the study of boundary spanners is limited because it has failed to examine the role of boundary spanners at complex boundaries. This gap can account for the continued negative impact of boundaries on GVPN project execution.

The purpose of this paper is to offer an initial exploration of how boundary spanners impact network performance within a GVPN that is characterized by boundary complexity. More specifically, our exploration focuses on the role of a cultural boundary spanner (CBS) within a GVPN composed of cultural, technical and knowledge domain boundaries. We examine the role of the CBS in terms of how she influences the efficiency of information transfer across knowledge domains between the geographically distributed teams that compose the network.

2. BOUNDARIES, SPANNING AND COMPLEXITY IN GVPNS

GVPNs are constituted by a number of co-existing and interdependent boundaries. The global aspect of GVPNs entails a geographic boundary, which, when workers are left in situ, necessitates the use of technology through which interaction is conducted. Geographic boundaries are addressed in GVPNs through the use of virtual communication media, which create technical boundaries. When workers are geographically distributed, they are likely to be ethnically and linguistically diverse, which can result in cultural boundaries. Because complex projects require collaboration between specialists, knowledge domain boundaries are also present. Thus, GVPNs are characterized by their cultural, technical and knowledge domain boundaries and require effective boundary spanners to facilitate information and knowledge sharing across all of these boundaries.

2.1 Boundary Definitions

To address the presence of geographic boundaries, GVPNs typically limit the opportunities for face-to-face interaction, which increases the need for interaction through technological mediation (Hinds and Bailey 2003). Different ICTs are used to facilitate the interactions, but often generate technical challenges, which can create boundaries within the GVPN (Hinds and Mortensen 2005). These technical boundaries often decrease the network's productivity. For example, in virtual meetings, time can be lost in preparing the ICTs and addressing problems such as poor audio and video quality. Technical boundaries can also decrease the network's efficiency in terms of information flow. The use of instant messaging and email may make it more difficult for network members to express their ideas clearly or comment effectively on a visual aspect of their work task. The email or instant message may be misunderstood or not understood at all, forcing the network members to interact several times, in order to successfully transfer the information required. In a face-to-face setting, misunderstandings can often be immediately clarified.

When GVPNs are composed of members from different cultures, misunderstandings may occur that can reduce the efficacy of information transfer between networked teams (Griffith and Harvey 2001). For example, cultural boundaries have the potential to negatively impact information flow at the planning, design and construction phases of a project (Mahalingham and Levitt 2007). Different cultures may have different aesthetic preferences, which may lead to resubmission of a design several times until accepted by owners from a different cultural background (Nayak and Taylor 2009). Mahalingham and Levitt (2007) describe a scenario where an American firm designed a building for a European client and did not fully understand the European preferences, which increased the design period of the project.

Knowledge domain boundaries arise in most GVPNs because the networks are composed of different teams with specialization in different aspects of the project (Gopal and Gosain 2010, Espinosa et al. 2003). For example, a GVPN could be composed of 3D modellers, schedulers and cost estimators. A knowledge domain boundary can exist when workers on each of these tasks are not cross-trained or lack specialization in one of the other knowledge domains. Knowledge domain boundaries can also occur when specialists have different motivations, goals, expectations and roles within a project that are linked to disciplinary cultures and values.

2.2 Boundary Spanning and Boundary Spanners

Existing research has explored strategies for spanning boundaries and achieving successful and efficient communication among GVPNs (Ramalingam and Mahalingam 2011). Boundary spanning involves gathering information from and transferring information across boundaries (Tushman and Scanlan 1981). Boundary spanners are individuals who enable communication and information exchange in networks composed of diverse teams (Cross and Parker 2004). For instance, a Cultural Boundary Spanner (CBS) has been empirically shown to help facilitate and reduce the negative impact of cultural boundaries in project networks (Di Marco et al. 2011). A CBS is a network member with experience in at least two of the different cultures represented in the network and can help bridge the cultural differences to enhance communication (Di Marco et al. 2010). Research has also demonstrated that a Knowledge Domain Boundary Spanner (KDBS) can increase the communication efficiency in networks composed of teams from different knowledge domains (Gopal and Gosain 2010). A KDBS is a network member who is cross-specialized and is able to “translate” knowledge between specialists in different knowledge domains. Other research has demonstrated that the use of a Technical Boundary Spanner (TBS) can help support interactions when network members are required to share information through a variety of ICTs (Ramalingam and Mahalingam 2011).

2.3 Boundary Complexity

Previous research has demonstrated that these boundaries often coexist, making it difficult for GVPN members to communicate and work together (Cummings 2004, Orlikowski 2002), which decreases communication efficiency (Wood 1986). Although research has proposed different alternatives to help span individual boundaries, very little has explored the role of boundary spanners in GVPNs characterized by multiple boundaries. For instance, Di Marco et al. (2010) analyse cultural boundaries and suggest the use of a CBS to help overcome the interactional difficulties associated with the boundary. However, because cultural boundaries often exist at knowledge domain boundaries, it is not clear what role the CBS plays in spanning knowledge domain or technical boundaries. We do not know the effect of a CBS on GVPN performance when the CBS is not simultaneously a KDBS and a TBS. Thus, there is a gap in our knowledge about the role of a CBS at knowledge domain and technical boundaries.

In this paper, we explore two cases where GVPNs are characterized by cultural, technical and knowledge domain boundaries and are either supported by a CBS or are not. We examine how the presence of the CBS affects GVPN effectiveness in terms of information transfer and project task execution. Thus, we pose the following, broad research question: What effect do CBSs have on information transfer when they are simultaneously positioned at cultural, knowledge domain and technical boundaries?

3. RESEARCH DESIGN AND METHOD

To answer these questions, we designed an experiment that allowed us to observe two GVPNs executing the design and planning of a hypothetical construction project. Each GVPN consisted of four teams of graduate students from four universities in India, the Netherlands, and the United States. Each network was composed of three Dutch cost estimators, two American construction schedulers, one American 4D modeller, and one Indian 3D modeller. In total, 14 students participated in the research. All interactions were conducted in English. Because English was the language of instruction at the American, Dutch and Indian universities, all participants had extensive experience collaborating in English on AEC design projects as part of their undergraduate course of study. However, participants' experiences working in virtual teams to execute this type of work varied between team members. The team composition simulates two GVPNs with cultural and knowledge domain boundaries.

To compare the role and impact of a CBS at these boundaries, we included a CBS in one network but not the other. The CBS we included had earned her undergraduate degree in India but was enrolled in graduate school in the U.S. She learned 3D modelling during her undergraduate studies and was learning construction scheduling in graduate school. She was well positioned to be both a CBS and a KDBS for the scheduling/3D modelling task, although she was not well positioned to span any boundaries constituted by the cost estimation knowledge domain. Although all participants had a basic familiarity with all three knowledge domains, each team used an analytical method and associated software applications that were unfamiliar to the other teams. For instance, the Dutch and Indian participants were exposed to the fundamental principles of construction scheduling in their introductory undergraduate classes, but neither group was familiar with the Simvision organizational modelling software that the American team used to build the construction schedule. Thus, the boundaries between knowledge domains coincided with technical boundaries for all participants except for the CBS because the CBS had extensive experience working with the 3D modelling software when she was an undergraduate student in India. Additionally, the nominated CBS was the only participant who was eligible to be a CBS because she was the only participant who had experience living and studying in more than one of the countries represented by the participant pool.

Because of the interdependence of tasks associated with this design project, all teams were required to iterate through the overall design with the 3D modellers. It was important for all teams to communicate with the 3D modelling team because the cost estimation and scheduling tasks were both interdependent with the 3D model. Misunderstandings about the 3D model would cascade throughout the tasks executed by the rest of the network. For example, in order to calculate the cost of the building, the estimators needed information on the materials and quantities used. If the 3D model changed, the other three tasks would be affected as well. This aspect of the experimental design created a need for information to flow across coexistent knowledge domain and cultural boundaries. Thus, because the CBS was positioned at the Indian cultural and knowledge domain boundary, she was well-suited to have a strong, positive effect on the interactions across boundaries within the GVPN.

During each of the two hour meetings over the three week study period, the GVPNs executed a different design task that contributed to a plan for modifying an existing three storey building. The team assigned to each task was responsible for managing and leading the work session for the week in which each of their respective tasks were executed. We focused on the 3D modelling, cost estimation and scheduling tasks because information transfer between teams would be necessarily high due to the task interdependence.

To create a technical boundary, we split each network into two sub-groups, who interacted with the network through two distinct and non-integrated ICTs. Communication occurred between the Dutch and American teams through the CyberGRID (Iorio et al. 2011), an ICT platform developed to support complex, geographically distributed engineering design work. The CyberGRID is a virtual world where users interact with each other through audio and text chat. In the CyberGRID, users can import 3D CAD models into the virtual space and interact with these models and with each other through avatars.

The Indian teams communicated with the Dutch and American teams in the CyberGRID through Google Chat (GCHAT), an instant messaging application where users can interact in real-time through text. Initially, we had planned to study all three teams working together in the CyberGRID and focus on analysing the role of the CBS in spanning the technical boundaries triggered by the construction design and planning software applications. However, due to challenges associated with the IT infrastructure in India and at the Indian University, connections to the CyberGRID from India were unreliable. Thus, our emergent experimental design reflects conditions present on many construction projects where a lack of reliable network connectivity and limitations on bandwidth (e.g. on construction sites in remote areas) impact the types of ICTs that can be used to support collaborative design and planning. The robust functionality of the CyberGRID as a virtual workspace in which design models can be represented visually and interacted with by geographically distributed teams of designers is limited when not all teams have access to IT infrastructure that is capable of supporting bandwidth-intensive applications. This context highlights the critical impact that IT applications and infrastructure can have on geographically distributed work and the importance of effective technical boundary spanning when a suite of ICTs must be used to facilitate interactions between teams.

In sum, technical boundaries were created between knowledge domains by the scheduling, 3D modelling, and estimating software in addition to the technical boundary created between the Indian and Dutch/American teams by differences in ICTs used to support collaboration. These types of technical boundaries are common in project-based industries, particularly in cases of joint ventures, as individual companies use proprietary software applications to execute discrete components of integrated project work. In turn, the GVPNs had to decide how to integrate the CyberGRID with GCHAT, and thus facilitate interaction between the Indian teams and the Dutch/American Teams. By introducing these technical boundaries, our design allows for analysis of the role that the CBS played in terms of facilitating information transfer across complex boundaries.

The six virtual meetings totalling 12 hours of interaction were recorded and analysed using ELAN, a multi-modal annotation software (Brugman and Russel 2004). For the analysis, speaker and addressee pairs were identified to capture who was talking to whom and conversations were transcribed with focus on distinguishing between task-specific information transfer and other types of interaction (e.g. rapport building). Our analysis focuses on the transfer of task-specific information transfer because this is the type of information that resides on different sides of a knowledge domain boundary.

Based on these processes, we used social network analysis (SNA) to analyse and visualize the information flows within the two GVPNs (Hanneman and Riddle 2011). We calculated the tie strength and information pathways within the GVPNs to capture how often and how efficiently information was transferred through the networks. Tie strength was calculated based on the frequency of interaction between members of the GVPN and were normalized to account for the different levels of interactivity in the two networks. Information pathways were calculated based on the number of links between two nodes representing information seekers and information holders. Thus, the information pathway value reflects the total number of direct and indirect pathways (e.g. through another node) that connect one node to another. A high pathway value suggests that information associated with a specific knowledge domain flows freely throughout the network, but may not be optimally directed to the destination node. To illustrate, a high pathway value from Node A to Node D suggests that, if Node A requires information from Node D, Node A could access the information through nodes B and C. If Node A has a low pathway value, then Node A may only be able to access information directly from Node D. In the former case, information is distributed evenly throughout the network. In the later case, information is specified in individual nodes, which is often the case in project work executed by specialized teams. Thus, for optimal information transfer between specialized project teams, we expect to observe low values for information pathways. The path analysis was used to compare the efficiency of information transfer between the GVPN with a CBS and the network without the support of a CBS.

4. DATA AND RESULTS

4.1 Tie Strength

To analyse the information flow across the complex cultural, technical and knowledge domain boundaries, we focused on interactions between the Indian 3D modelling team and the rest of the network since the CBS was positioned at this cultural and knowledge domain boundary. The tie strengths (i.e. the number of interactions) for all meetings of both networks are presented in TABLE 1. For both networks, we observed that the Indian 3D modelling team had higher tie strength values than either the Dutch estimation team or the American scheduling team. This pattern aligns with the leadership role that the Indian team had during the 3D modelling task, i.e. that we expected the 3D modellers to be most engaged during the meeting when their task was central. We treated the ties with the 3D modellers during the 3D modelling meeting as a baseline case, which we compared to their ties during other meetings where they are not required to be as central. The communication network for the GVPN with a CBS involved in the execution of the 3D modelling task is included in FIG. 1.

TABLE 1. Tie strengths for the 3D modelers by task type

Week	Task	GVPN with CBS	GVPN with no CBS
1	3D Modeling	23	36
2	Cost Estimation	12	11
3	Scheduling	8	11

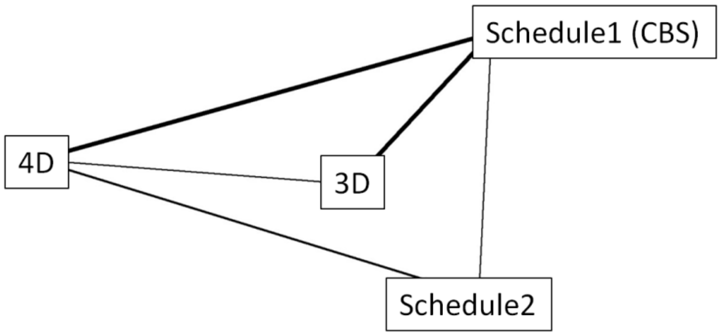

FIG. 1: GVPN communication network with CBS executing the 3D modelling task

During the cost estimation meeting (FIG. 2), we observed the same pattern in tie strength as we observed during the 3D modelling meeting, i.e. that the ties for the team leading the meeting were highest. In this case, Cost1 demonstrated the highest tie strength because the cost estimators required information from the rest of the network in order to complete their estimation. Because their role was not as central during the cost estimation task, the tie strength for the 3D modellers was reduced to 12, nearly half its value during the 3D modelling task.

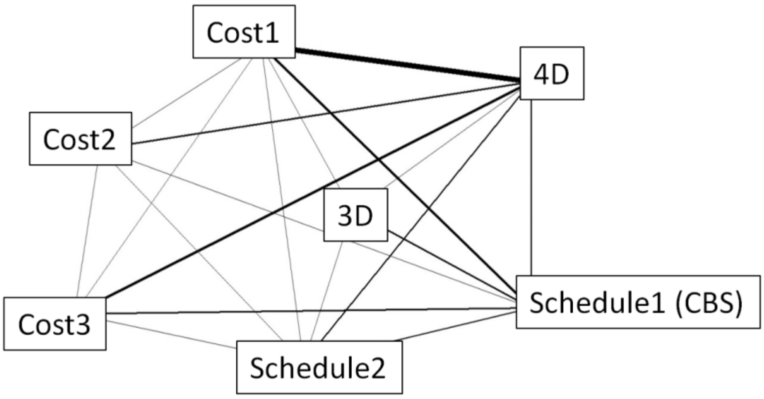

FIG. 2: GVPN communication network with CBS executing Cost estimation task

During the scheduling task (FIG. 3) the tie strength for the Indian 3D modelling team continued to decline, reaching its lowest value of nearly one third that of the 3D modelling meeting. Because scheduling was the final task in the development of the project, the American scheduling team needed input from each of the other teams to ensure all building components and related construction processes were accounted for when calculating the final construction duration.

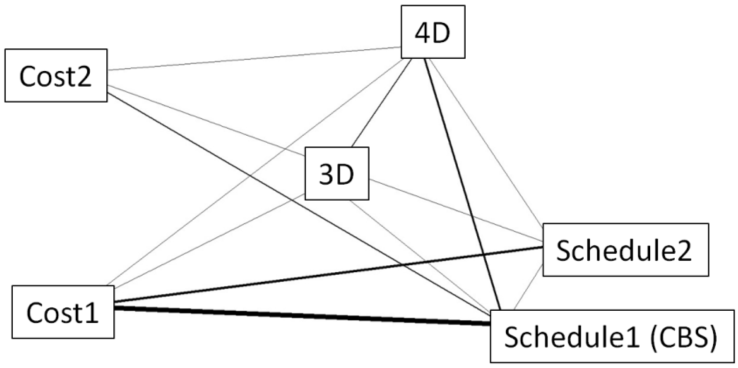

FIG. 3: GVPN communication network with CBS executing the scheduling task

Over the three weeks of the study period, we observed a decrease in participation by the 3D modellers even though the information about the 3D modelling process was central to the cost estimation and scheduling tasks that were to be executed in subsequent weeks. Over time, the GVPN came to depend more often on the CBS to communicate with the 3D modellers across the technical, cultural, and knowledge domain boundaries rather than directly communicating in order to meet their information needs. EXAMPLE 1 demonstrates this emergent dependence on the CBS and the indirect pathways that information can take in a complex boundary environment.

1. Cost to GVPN: There are indeed still a lot of mistakes in the design […] we also made a list of all the faults in the design, so there is still some action from our colleagues in India.
2. CBS to Cost: It will be great if you guys can share with [India].

   […]
3. Cost to CBS: So your responsibility number 1 is that you will keep trying to contact with the other group, the group from India.
4. 4D to Cost: Yea sounds good.
5. Cost to 4D: Ok, well that's fine.

   […]
6. CBS to GVPN: Let's go to the other room so I can project the chat with [India] while we fix the GCGAT so everyone can join us. Can we go?

EXAMPLE 1: Transcript demonstrating how the GVPN interacts with the 3D modelling team through the CBS

In Lines 1 and 2, EXAMPLE 1, rather than communicating directly with the Indian 3D modellers, the Dutch cost estimation team is describing the problems with the 3D model to the CBS, with the unstated expectation that she will relay the problems to the Indian team. The presence of the technical boundary facilitates this indirect information flow, because, if the 3D modellers were located in the CyberGRID along with the Dutch and American teams rather than on GCHAT, the exchange in EXAMPLE 1 would be awkward as the Dutch would be talking about the Indian team as if they were not present. The technical boundary allows the Dutch to interact directly with the CBS without requiring interaction with the Indian team. If the 3D modellers would have been in the same technological space as the cost estimators, we assume that Cost would have directly addressed his issues and concerns to the 3D modellers.

EXAMPLE 1 is also illustrative because it demonstrates how the CBS was positioned at an inappropriate knowledge domain boundary and the difficulty that the CBS had in removing herself from this position. Lines 3-5 show how the Dutch cost estimation team assigned the CBS a TBS role, noting that the CBS's primary responsibility was to communicate with the Indian team. Line 6 demonstrates that the CBS attempted to facilitate more direct contact between the cost estimators and 3D modellers, thus encouraging more direct interaction between the knowledge domains. Note that EXAMPLE 1 was drawn from interactions that occurred during the first meeting of the network.

EXAMPLE 2 was taken from the final meeting of the network and suggests that the CBS was never able to be effectively repositioned from the cost estimation/3D modelling knowledge domain boundary. The inefficient interactional patterns where information was directed between knowledge domains through the CBS continued throughout the project and culminated in EXAMPLE 3. In Line 1, the CBS is asking the 4D modelling team to communicate directly with the 3D modelling team, while in Line 2, the CBS is asking the 3D modelling team to include the 4D modelling team in their email. This example suggests that the information pathways through the network are dependent on the CBS.

1. CBS to 4D: Can you please log in to GCHAT so we can quickly coordinate with [India]?

   […]

2. CBS to 3D: Can you please include the 4D modeller and others in the email thread!

EXAMPLE 2: Transcript demonstrating the effort of the CBS to encourage direct interaction across knowledge domain boundaries

The increased centrality of the CBS in the network interactions grew out of the CBSs early efficacy in spanning the cultural and technical boundaries that were present in the GVPN. EXAMPLE 3 demonstrates one case where the CBS effectively spanned a technical boundary by aiding the Dutch team in understanding how and why the team was using GCHAT to interact with the Indian team. In this role as a TBS, the CBS ensured that the technical boundary was not preventing the American and Dutch teams from interacting with the Indian team.

1. CBS to Cost: Guys, I have sent you a GCHAT invitation, can you please accept it and join us?
2. Cost to CBS: Yea, I haven't seen this before, so I have to figure it out.
3. Cost to CBS: And what is this, I have to click on the link?
4. CBS to Cost: Yes, and follow the instructions.
5. Cost to CBS: And why do we use this GCHAT?
6. CBS to Cost: Because [India] cannot log in to the CyberGRID and this is one means that we can communicate with them.
7. Cost to CBS: Ok.

EXAMPLE 3. Transcript demonstrating how the CBS is effective in the role of a TBS

Having explored the interactional dynamics of the GVPN supported by a CBS, we turn next to a comparison with the GVPN that was not supported by a CBS. As we observed with the CBS network, the 3D modellers in the network without a CBS had the highest tie strength compared to other teams when performing the 3D modelling task (c.f. FIG. 1, FIG. 4). During this meeting the 3D modellers had a tie strength value of 36, more than three times higher than during the cost estimation and scheduling weeks. Again, this pattern makes sense because the 3D modellers were responsible for leading the 3D modelling meeting.

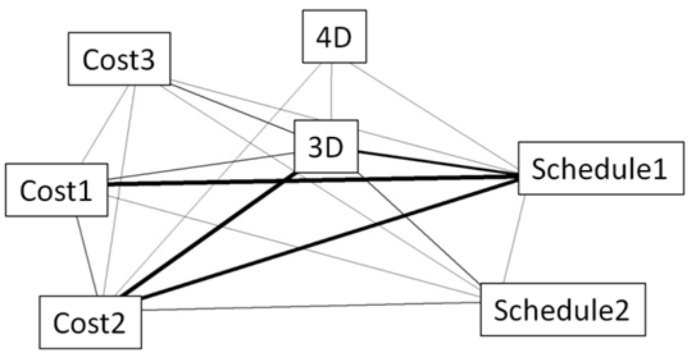

FIG. 4: GVPN communication network with no CBS executing the 3D modelling task

FIGS. 5 and 6 show the interactions in the GVPN with no CBS during the cost estimation and scheduling meetings. Again, as we observed for the network with a CBS, during these two weeks, the tie strength values of the 3D modellers decreased over time. When comparing the tie strength values of the 3D modellers from each GVPN (TABLE 1), the key difference lies in the 3D modelling week, where the normalized tie strength for the network with a CBS was 23 compared to 36 for the network without a CBS. This difference suggests that the CBS played a role in filtering the direct interactions between Dutch and Americans on one side of the technical boundary and the Indians on the other side. This finding is reinforced by EXAMPLE 2, which demonstrates how the network came to create a dependency on the CBS to communicate with the 3D modellers.

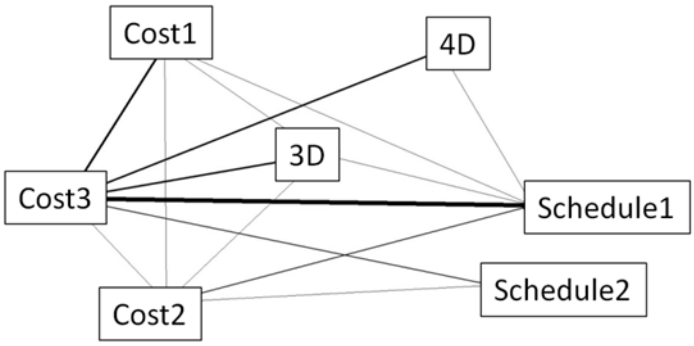

FIG. 5: GVPN communication network with no CBS executing the cost estimation task

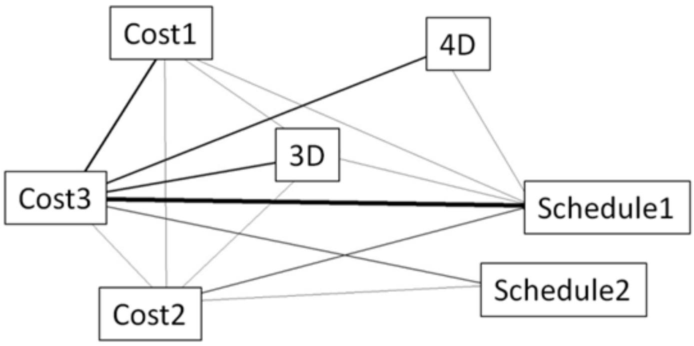

FIG. 6: GVPN communication network with no CBS executing the scheduling task

4.2 Network Efficiency

Although our analysis to this point has demonstrated differences in the interactional dynamics of GVPNs supported by a CBS and those that are not, the differences may not necessarily impact the efficiency of the network in terms of information transfer across the complex boundaries. In other words, our analysis to this point has not captured whether the placement of the CBS on paths leading to the 3D modellers negatively impacts information transfer throughout the network. To measure the efficiency in which information is transferred from the 3D modelling team to the rest of the GVPN, we calculated the number of information pathways between the 3D modellers and the other teams (TABLE 2).

TABLE 2. Information pathways between the 3D modelers and other knowledge domains

Team	GVPN with CBS	GVPN with no CBS
Cost Estimation	19	6
Scheduling	9	4

In Figure 2, much of the information needed by the cost estimators to accomplish the task travels through the CBS even though the CBS is not on a team that requires the information to execute the cost estimation task. The cost estimators had to communicate with the 3D modelers to calculate an accurate estimate. They needed specific information about the different materials, quantities and measurements of the building modification. The

CBS was part of the scheduling team and yet, most of the information requested of the 3D modelers was transferred through the CBS. More specifically, information traveled through 19 information pathways between the cost estimators and the 3D modelers. This is a relatively high number of pathways being more than twice as many pathways than in the scheduling week, reflecting that information was not transferred efficiently.

EXAMPLE 4 shows how the CBS served as an interactional link between the cost estimators and the 3D modelers, which led to an increase in information sharing pathways that we do not observe in the network without a CBS. In EXAMPLE 4, the cost estimation team wanted the 3D modeling team to adjust the 3D model to match their cost estimate. Rather than communicating directly with the 3D modelers through GCHAT, they asked the CBS to communicate with the 3D modelers. This suggests that the cost estimators were trying to leverage the Indian cultural link between the CBS and the 3D modeling team and served to position the CBS at an inappropriate knowledge domain boundary since the CBS did not have knowledge associated with the Dutch cost estimation process. We also see this occur after the interaction in Example 1, where the CBS explicitly attempts to forge a direct connection between the Dutch and the Indians.

1. 3D to CBS (Google Chat): The wall *you* want deleted is in level 2?

2. CBS to Cost (CyberGRID): The wall that you guys are talking about is in level two correct?

3. Cost to CBS (CyberGRID): Yes.

4. CBS to 3D (Google Chat): Yes only the wall on level 2, nothing on the top floor.

EXAMPLE 4: Transcript demonstrating how the CBS has become incorrectly associated with the cost estimation knowledge domain (emphasis added)

Because the Dutch team repeatedly and consistently interacted with the Indian 3D modeling team through the CBS, the 3D modeling team eventually came to associate the CBS with the cost estimation knowledge domain rather than the scheduling domain. We see evidence of this in the first line of Example 4 as the 3D modelers ask the CBS "the wall you want deleted is in level 2" (emphasis added). The 3D modelers posed their question directly to the CBS as if the CBS required the information. This indirect information pathway led to confusion, as the CBS did not completely understand the changes to the model that the cost estimators requested. This type of scenario occurred repeatedly in the GVPN with a CBS and resulted in the creation of more information pathways than were required. TABLE 2 shows that the GVPN with a CBS had three times more information pathways compared to the GVPN without a CBS.

Conversely, when the GVPN with the CBS performed the scheduling task (FIG. 3), the number of information pathways between the 3D modeling team and the scheduling team decreased from 19 to 9, which suggests that the information flow was more efficient. In this case, the CBS was also appropriately positioned as a KDBS. Positioning a CBS at an appropriate knowledge domain boundary resulted in a more efficient network structure characterized by fewer information pathways and more direct interaction between information seekers and holders. In turn, information was not filtered by the CBS because the CBS was simultaneously a KDBS.

When analyzing the number of information pathways between the 3D modeling team and the other teams in the network that did not include a CBS (Figures 5 and 6), we discover that the number of pathways are much smaller and less variable than for the GVPN with the CBS (TABLE 2). These differences between the two types of networks highlight the potentially disruptive role that the CBS can play when they are inappropriately positioned at a knowledge domain boundary.

5. DISCUSSION

Past research has demonstrated that a CBS can improve project performance in global teams that interact in a face-to-face setting when the CBS is able to shift from a highly central position to a position on the periphery while facilitating more direct interaction between team members (Di Marco et al. 2010). In these cases, inclusion of a CBS can improve communication within the team across the cultural boundary when compared to the team that was not supported by a CBS. Our results support those of Di Marco et al. (2010) as our findings also suggest that a CBS can be effective at improving information transfer in global teams characterized by a cultural boundary. However, because GVPNs are complex boundary environments (Espinosa et al. 2014) with multiple, co-occurring boundaries, it was unclear whether a CBS would be effective in a global virtual team where the interactions are mediated through ICTs.

Research by Ramalingam and Mahalingam (2011) explored the efficacy of a CBS in a global virtual team and found that when the CBS was also competent in resolving the technical challenges faced by the team as a result of interaction through ICTs, the CBS emerged as a TBS and was effective at spanning both the technical and cultural boundaries. Again, our results confirm this finding, which is evident in EXAMPLE 3 as the CBS works with the GVPN to help them understand: 1) how to operate the ICT, and 2) the role that the ICT plays in the global virtual collaborative process.

However, to date, research has not determined whether a CBS is effective at spanning the complex boundaries that characterize the global virtual project networks, as these networks are composed of specialist teams and require information to be transferred across knowledge domain boundaries. Our results suggest that a CBS may not be effective when the cultural boundary coincides with a knowledge domain boundary in which the CBS is not a specialist. In our research, when the CBS was positioned at a knowledge domain boundary for which she did not have the required specialization, information was inefficiently transferred. For instance, in one case, information from the 3D modeling team traveled through 19 different pathways to get to the most central member of the cost estimation team because the information was being routed through the CBS when the CBS was not familiar with the costing techniques and requirements of the cost estimation team. In contrast, because the CBS was a specialist in both construction scheduling and 3D modeling, information traveled across this knowledge domain boundary through only 9 paths. Our results serve to distinguish the role of a CBS in GVPNs compared to both global teams and global virtual teams as a product of the increased boundary complexity that is associated with these types of networks. We generalize these results in the following proposition:

Proposition 1: Because global virtual project networks are complex boundary environments that consist of cultural, technical and knowledge domain boundaries, each boundary must be spanned in order to positively impact project performance.

Abstracting our results to the larger context of global project work and situating it within the existing literature, we present a theoretical model (FIG. 7) that captures the relationships between boundaries, the work structures that they characterize, and the types of boundary spanners that are required to improve project performance.

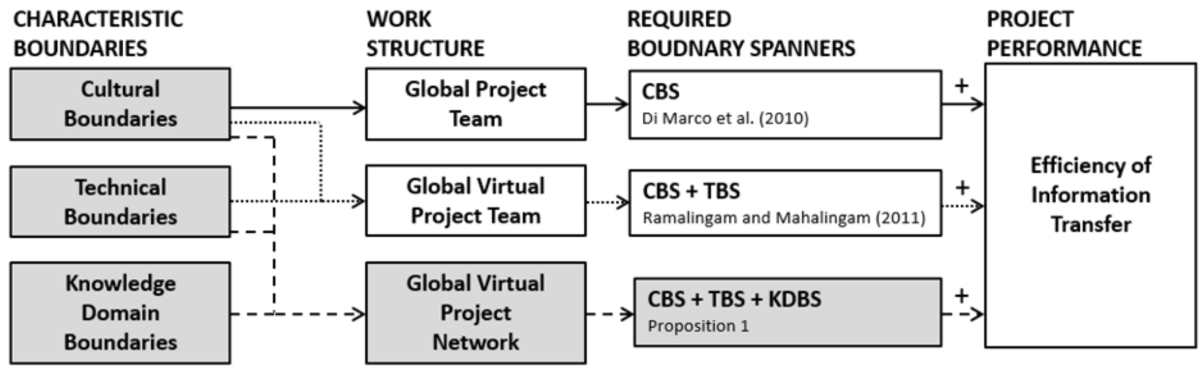

FIG. 7: Theoretical model linking boundaries, work structures, boundary spanners and project performance

The key contribution of the model is that it reflects a more nuanced formulation of boundary complexity within GVPNs and the often difficult role for boundary spanners to shift from the center of the network to the periphery (Di Marco et al. 2010) when navigating the multiple, co-occurring boundaries. This difficulty is similar to those described for process facilitators in GVPNs (Iorio et al. 2012). Even though the facilitators were far outside the knowledge domains of each team in the networks, the GVPN developed an interactional dependency on the facilitators for transfer of information throughout the course of the project. The facilitators were initially successful at implementing a process map and troubleshooting interactional challenges due to the ICTs. Their effectiveness positioned them at the center of the network at the beginning of the project, but as the scope of the project work entered into the specialized knowledge domains, the facilitators remained the central points of information transfer, which resulted in an increased level of task conflict

Both our research and the research conducted by Iorio et al. (2012) suggest that boundary spanners can be counter-productive by interfering with direct interactions between members across knowledge domain boundaries. In the GVPN we studied that was supported by a CBS, the tie strength for the 3D modelers decreased over time, which suggests that the network became more dependent on the CBS for information transfer. Because of the centrality of the CBS, indirect interactions through the CBS across the cultural boundary with the 3D modeling team in India became normative. In contrast, for the network without a CBS, interaction across this cultural boundary was direct between information holders and seekers, which ensured that, as task types shifted across knowledge domain boundaries, information was transferred more efficiently.

To prevent the types of inefficiencies in information transfer that we have highlighted in our research due to the inappropriate placement of a CBS at certain knowledge domain boundaries, we suggest more explicit role assignment and inter-team coordination during the early stages of the project (Hoegl et al. 2004). Levina and Vaast (2005) argue that a boundary spanner must have the ability and inclination to participate in the network interactions. By explicitly defining and coordinating roles early in the project life cycle, GVPNs may be able to improve the ability of CBSs to reposition themselves when they are drawn to the center of interactions across inappropriate knowledge domain boundaries. As we saw in EXAMPLE 2, although the CBS may have the inclination to directly connect network members to information across knowledge domain boundaries, the interactional norms that emerge within GVPNs may countermand the ability of the CBS to do so.

6. FUTURE RESEARCH AND LIMITATIONS

Although our research suggests that a CBS may not be effective when they are also positioned at certain knowledge domain and technical boundaries, future research is needed to further explore the role of a CBS in complex boundary environments that characterize GVPNs. For instance, we chose a highly controlled experimental design with graduate students as participants in order to develop our proposition and theoretical model. Many of the graduate students were not cross-trained in the tasks associated with the knowledge domains and some may have not been confident in their knowledge of their assigned project tasks. Both of these factors may have impacted the willingness of the participants to interact with members of other geographically distributed teams. Moreover, our research did not control for the gender of the participants, their experience working in industry, or any AEC knowledge they gained outside of their formal professional training. However, in real-world project work, project teams are often characterized by the diversity of gender and experiences of the team members. In an industry setting, we also would expect that certain members of the GVPN would be cross-trained. By examining CBSs with expertise across multiple knowledge domains, our theoretical model could be validated for overall project performance, rather than performance on the individual tasks that constitute the project. Our research has demonstrated that a CBS can effectively span multiple boundaries when they are simultaneously an appropriate TBS and KDBS. However, in larger-scale, more complex projects, it may be difficult to identify a single network member who is capable of effectively filling all of these roles. Thus, future research can productively examine the dynamics of multiple boundary spanners employed for the same project and identify whether multiple or specialized boundary spanners are better suited to support the interactional needs of the network.

Because our sample size was small, substantive conclusions about the role of CBSs in GVPNs at complex boundaries are difficult to generalize from our findings, although small scale studies are often the first step in the development of theoretical models (March et al. 2003) such as the one proposed herein. Our research has demonstrated that in the case we studied, a CBS was effective at spanning some but not all of the boundaries that characterize the network. The challenge for future research is to identify the conditions necessary that make CBSs effective at spanning multiple boundaries toward the goal of better understanding how human and technological supports can be best leveraged to improve the performance of GVPNs.

7. CONCLUSION

Given the rise of global virtual project networks as organizational structures in response to the globalization of the architecture, engineering and construction industry, in the future, we expect the boundaries that characterize these networks to increase in multiplicity and complexity. For the industry to continue to execute projects effectively in a global economy, we need a more robust understanding of the role that human support structures, coupled with ICT, can play in facilitating efficient information transfer across these boundaries. We found current research on the impact of cultural boundary spanners in global project networks to be inadequate to characterize the interactions in a virtual setting. In order to enable the cultural boundary spanning efficiencies described in earlier research, we found that cultural boundary spanners must be able to span boundaries across which they share specialized knowledge. Thus, our research increases our understanding of the challenges to effective boundary spanning in complex boundary environments such as global virtual project networks.

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