Deriving IT-Mediated Task Coordination Portfolios for Global Virtual Teams

Sutanto, J., A. Kankanhalli, and B.C.Y. Tan

Forthcoming IEEE Transactions on Professional Communication

Abstract – *Global virtual teams (GVTs) can provide benefits in terms of lower costs and enhanced performance. However, the realization of these benefits depends on effective GVT task coordination, which faces significant challenges due to time-zone differences and geographical dispersion. Further, there is a lack of understanding of optimal IT mediated coordination mechanisms for these teams. Based on an in-depth study of project tasks carried out by three GVTs, we uncovered IT-mediated task coordination portfolios (sets of mechanisms) used for effective coordination. The portfolios should fit GVT's task dependence, members' common time frame, and perceived time constraints in order to be effective.*

Index Terms – *Action theory of dialogue, global virtual teams, IT-mediated task coordination portfolios, media naturalness, task coordination, task dependence.*

With rapid advancements in information technology (IT), organizations are able to compose teams for various organizational tasks with members from different parts of the globe. This form of distributed team structure is known as a global virtual team (GVT) [1], [2]. GVT can offer a multitude of organizational benefits such as cost savings and improved performance by leveraging expertise and resources from different locations [3]. For example, GVT members working on a market survey can aggregate their location-based information for a comprehensive plan, and global teams developing software can tap members' time zone differences to attain "a 24-hour working day". However, the realization of these benefits depends on the way GVT members manage and coordinate their interdependent actions, which is termed as task coordination [4]. For example, team members working on a software system may utilize a development blueprint to ensure interoperability of the software components and minimize redundancy of efforts.

Having team members working in different geographical locations presents significant challenges to task coordination [5], [6]. For instance, GVT members located in North America and Asia could find it problematic to schedule a meeting due to their large time zone difference. Also, dispersed members developing a software package may carry out duplicate work due to their different interpretations of the software design blueprint. Poor task coordination could result in "process losses", where GVTs' actual productivity is less than what is expected. In certain cases, an entire work overhaul may be required, which significantly adds to the total amount of time needed to deliver the project [7]. With these challenges, our understanding is lacking on how effective task coordination can be attained in IT-mediated environments of GVTs.

Research on task coordination posits that coordination could occur in two ways: *implicit*, i.e., based on unspoken expectations and intentions, and *explicit*, i.e., based on formally adopted plans or agreements that designate who is to do what and when they are to do it [4]. While both forms of task coordination are important, explicit coordination is often required as effective implicit coordination can occur only when team members have prior shared work experience or

are familiar with one another (e.g., [8]-[10]). Since GVT members are typically chosen due to their expertise and less because of their experience with one another, relying solely on implicit coordination could be problematic. Thus, achieving effective explicit task coordination can be crucial to team performance. Therefore, this study focuses on how to attain effective explicit task coordination in GVT.

Previous research has provided mixed results of what mechanisms are effective for explicit task coordination in distributed teams. While some studies have proposed frequent communication, in addition to standardization and scheduling mechanisms for effective task coordination in such teams e.g., [5], [11], a survey by Hinds and McGrath [12] found that GVTs with frequent communication actually experienced more (not fewer) task coordination problems. With these contradictory findings, Hinds and McGrath [12] highlighted the need to properly align the intensity of coordination through communication mechanisms with GVT structures (e.g., task and members' characteristics). This call is also echoed by Massey et al. [13] who noted that further research is needed to examine the effects of alternative coordination mechanisms and how to match an appropriate mechanism to the team's task. Our study thus aims to address the question of how to match task coordination mechanisms to GVT structures with the objective of effective task coordination. Effective task coordination is reflected and assessed by task completion without engaging in unnecessary work or duplication of efforts [4].

Without clear direction in the GVT literature on how to design effective task coordination, we turned to task coordination studies in collocated teams where researchers have proposed to match the set of task coordination mechanisms to the type of the team's task dependency for better coordination (e.g., [14]-[16]). In our study, we term the set of task coordination mechanisms used by a team for a task as the *task coordination portfolio*. Previous research on collocated teams suggests that a team with relatively high task dependence needs frequent communications besides standardization and scheduling mechanisms to attain effective task coordination; whereas a team with relatively low task dependence can rely on standardization and scheduling mechanisms alone [14]-[16]. However, communication dialogue researchers have argued that creating coordinated action solely through standards and schedules that people are compelled to agree to may be problematic [17]. This is especially true in a distributed team context where there could be a lack of shared meaning of the standards and schedules, which members may not be aware of until they experience redundant and unnecessary duplication of efforts [1]. This study aims to reconcile the suggestions from task coordination theory in collocated teams and action theory of dialogue for the GVT context. Whether the proposed task coordination designs for collocated teams are applicable in the GVT context or how they should be modified is of interest in this study. We are also interested to investigate factors other than task dependence that may affect GVT task coordination design.

To extend the proposed designs for collocated teams to GVTs, we seek to understand the types of IT that can support GVT task coordination. This is because in GVT, where face-to-face interaction is significantly limited, the task coordination mechanisms would mainly need to be mediated through various IT. Nonetheless, since the human brain is genetically programmed to excel in collocated and synchronous interactions, deviation from such conditions in GVTs is likely to put an extra burden on the brain [18], [19]. Media naturalness is the ability of an IT to support a sense of collocated and synchronous interaction by employing facial expressions, body

language, and speech [18]. Building on media naturalness theory, we will investigate the types of IT that can optimally support different mechanisms of GVT task coordination.

To sum up, while there is a consensus on matching task dependency to task coordination portfolios for effective task coordination in collocated teams, there is no clear direction on how to design effective task coordination in GVTs. This study attempts to address the questions: What factors other than task dependence affect GVT task coordination design? How should IT-mediated task coordination portfolios match the influencing factors for effective GVT task coordination? To answer these questions, coordination of all project tasks in three GVTs was analyzed in-depth and compared. This study is expected to contribute to research and practice by improving the understanding of how effective IT-mediated task coordination can be achieved in GVTs.

CONCEPTUAL BACKGROUND

As a conceptual foundation for our study, we refer to: 1) task coordination theory in collocated teams as our initial basis for investigating optimal task coordination portfolios for GVT, 2) action theory of dialogue to explain how to attain shared understanding through task coordination mechanisms in GVT, and 3) media naturalness theory to understand how the task coordination portfolios derived from collocated team theory may be optimally mediated by IT for GVT.

Task Coordination Theory in Collocated Teams The general tenet of task coordination in the collocated team literature is that for effective task coordination, there should be a match between the team's type of task dependence and its set of task coordination mechanisms [14], [16], [20]. Four types of task dependence have been proposed [16], [21] (see Fig. 1). In a *pooled dependence task* each member's part is independently completed, followed by aggregation. A *sequential dependence task* involves the completion of one part before the other begins. As opposed to sequential dependence tasks that move in one direction, *reciprocal dependence tasks* flow in a "back and forth" manner between members. In a *team dependence task,* all members concurrently diagnose, problem-solve and collaborate as a group to deal with the task; hence there is no measurable temporal lapse in the flow of work among team members in such a task.

[Insert Fig. 1 about here]

An overall hierarchical relationship is suggested among the types of task dependence (i.e., higher levels of task dependence as supersets of lower levels of task dependence) with team dependence being the most complex and including all other forms of dependency below it, i.e., pooled, sequential, and reciprocal [22]. For example, during brainstorming for a new marketing survey, there are pooled, sequential, and reciprocal dependence activities when team members prepare for the survey ideas on their own, take turns to present their ideas, and answer questions regarding their presented ideas.

To coordinate tasks with different types of dependence, corresponding task coordination mechanisms have been suggested. Task coordination mechanisms have been categorized in various ways, based on the mode of communication employed and the communication partners involved. Among them, the classification of task coordination approaches as rules or standards,

plans or schedules, and mutual adjustment, has been found to be useful and validated over time [20], [23]. The common element of coordination through *standards and plans* is that a codified blueprint of action is specified prior to the commencement of the task [16]. Their use should require minimal communication between task performers. In contrast, coordination through mutual adjustment uses interpersonal interaction while members are working on the task [23]. It may take place between superiors and subordinates (*vertical* communication) or between peers (*horizontal* communication) [24]. *Team meetings* differ from mutual adjustments by the simultaneity of multilateral interactions [16]. Whereas mutual adjustment through vertical or horizontal channels is done by individual members, in team meetings the entire group or a significant subset would be involved in the coordination.

In collocated teams it has been proposed that the use of the appropriate coordination portfolios for the particular type of task dependence may lead to effective task coordination (see Fig. 2), which is indicated by task completion without members doing extra work or unnecessary duplication of efforts [4]. Pooled tasks should be primarily coordinated by predetermined standards and sequential dependence tasks should be coordinated by plans [22]. Since sequential tasks contain pooled tasks, the task coordination portfolio (as per our study terminology) for sequential tasks should contain both predetermined standards and plans. Since reciprocal tasks require back and forth interactions among task performers whose form, direction, and content of interaction often cannot be anticipated in advance, they should be mainly coordinated by vertical and horizontal communication channels [22]. Thus the optimal task coordination portfolio for reciprocal tasks should contain standards, plans, vertical, and horizontal communication. Further, since team meetings can facilitate interactions among members and offer them an opportunity to clarify doubts and coordinate their tasks directly with one another [25], the optimal task coordination portfolio for team dependence tasks should contain predetermined standards, plans, vertical, horizontal communication, and team meetings.

[Insert Fig. 2 about here]

While the proposed task coordination design in collocated teams (Fig. 2) serves as our initial basis for investigating optimal task coordination portfolios for GVT, it is important to note that the above fit principle assumes that collocated members have common interpretations of the task coordination messages sent through various mechanisms; thus enabling them to avoid redundant and duplicate efforts. However, when team members are geographically dispersed, there could be a lack of shared meaning [1] as well as the need for IT mediation of task coordination portfolios.

Action Theory of Dialogue Dialogue provides the means for transcending differences of interpretations prior to organized action, as well as for retrospective sense-making about actions that have been taken [17], [26], [27]. Particularly for task coordination, according to action theory of dialogue, creating coordinated actions through predetermined standards and plans could be problematic [17] due to team members disagreeing with or misinterpreting the standards and plans. To attain shared understanding, it is suggested that team members should become conscious of and speak to the whole group, not simply to one person [17]. Thus, vertical and horizontal coordination mechanisms may not be adequate to create shared understanding. Rather, there should be an effort to expand the capacity of a group of people to inquire into and

alter the shared "field" or background conditions [17]. One way to expand such capacity is through the team meeting coordination mechanism.

This suggestion contradicts task coordination theory in collocated teams which proposes that predetermined standards and plans are adequate to coordinate lower dependence tasks. Thus, we are interested to reconcile the suggestions from the two theories by investigating the effective task coordination mechanisms in the GVTs studied. Moreover, since GVT members rely extensively on IT to communicate, task coordination effectiveness may also depend on the IT used to mediate their task coordination. When the face-to-face (i.e., the most natural [18]) medium is rarely available, the need for naturalness of IT mediation may pose obstacles for effective coordination.

Media Naturalness Theory Media naturalness refers to the ability of an IT to support a sense of collocated and synchronous interaction by employing facial expressions, body language, and speech [18], [19]. There are two main classes of IT that can be utilized in support of task coordination: repository and communication support technology [28]. A repository is a shared knowledge base that provides information processing support; whereas communication technology provides either asynchronous (e.g., email) or synchronous (e.g., conferencing) communication support [29], [30]. A repository (e.g., bulletin board) is the least natural medium in terms of synchronous interaction. Low media naturalness is related to high cognitive effort (i.e., high mental activity involved in a communication interaction), high communication ambiguity (i.e., high probability of misinterpreting the communication cues), and low physiological arousal (i.e., low excitement resulting from the use of the medium) [18], [19]. A repository however offers the most permanent and indexed meta-information for easy storage and retrieval. Since coordination through predetermined standards and plans may not require intensive communication but task performers should be able to easily retrieve them, a repository seems to be optimal to support standard and plan task coordination mechanisms in GVT. Synchronous media (e.g., teleconference, videoconference) generally have higher degree of media naturalness as compared to asynchronous media (e.g., email) [28], and thus seem to be optimal to support coordination mechanisms that necessitate communication and feedback, such as vertical, horizontal, and team meeting task coordination mechanisms. We will investigate whether these recommendations for optimal IT-mediated task coordination portfolios hold for the teams in our study.

RESEARCH METHOD

Building on the theories and concepts discussed above, we adopted an exploratory case study approach. To ensure rigor, we followed the suggested guidelines of research design, data collection, and data analysis for positivist exploratory case study research [31].

Research Design The three GVTs in this study, labeled as teams A, B and C, are organization sponsored teams that consisted of Master level students located in universities across Asia, North America, and Europe. Team A was dispersed across two continents while teams B and C were dispersed across three continents. Having globally-dispersed members and relying mainly on IT for communication and collaboration activities, they fulfilled the necessary characteristics of GVTs. All participants did not know each other before the teams were formed. They had at least

two years' work experience, had never worked in GVT before, and were selected by the organizational sponsors based on their skills and expertise to work on specific projects for five months. Thus there were no systematic differences in capability among the three GVTs. Each GVT was monitored by a project manager from the sponsor organization. At the end of their projects, the teams had to submit a written report and present the results to their respective sponsor organizations. Both the faculty members and organizational sponsors then jointly awarded the grades to the teams. The projects of the GVTs consisted of several tasks as shown in Table I, which served as our unit of analysis as well as our replication logic of the multiple case design [31]. In total, there were 13 tasks representing different types of task dependence. The type of task dependence was classified by two researchers and then confirmed with the project managers.

[Insert Table I about here]

All teams were provided with technology for email, teleconference, video conference, bulletin board, and instant messaging (ICQ). The bulletin board was linked to the course website from where members of all teams could post text messages. Team members could conduct teleconferences from their personal computers. However, for videoconferencing they had to book and use a separate videoconference room. There was only one videoconference room in each location. Except email, team members had little experience with the other media. Basic training was given in using these technologies. To control for potential extraneous influence due to IT reliability and access speed [28], [29], we checked the technologies provided in every location to ensure that they were similar in terms of these properties.

Data Collection Different roles for multiple investigators encourage the development of independent views that can then be compared [31]. In our study, two authors were directly involved in the data collection while the third author remained an outsider to challenge the objectivity of the study. Table II shows our multiple data sources over the five-month duration of the projects. Each source added richness and strengthened theory grounding by triangulation of evidence [31]. The data was gathered mainly through objective sources i.e., communication logs and documentation. The communication logs are suitable to identify the task coordination mechanisms used and their IT mediation. All e-mail logs, ICQ logs, and bulletin board postings were recorded. Some teleconferences were recorded and transcribed while detailed meeting minutes were available for the unrecorded meetings. Minutes of videoconferences were obtained and recordings transcribed. All project documentation, including project reports and members' lesson-learned papers, were analyzed.

[Insert Table II about here]

Data Analysis Each task in a GVT project constitutes our unit of analysis i.e., total 13 (see Table II). Data analysis was carried out through template coding [32] and axial coding [33] on all communication logs, transcriptions, and documentation. Template coding structures the analysis process by developing a priori categories and subcategories [32]. With this approach, better grounding of construct measures can be achieved [32]. Based on our literature review, the original template for our study is shown in Table III. However, we allowed for new findings to emerge that could redefine our initial perspective [34], [35].

[Insert Table III about here]

During the data analysis and as a result of a growing understanding of the phenomenon, the codes in the original template were adjusted and new codes inserted to retain theoretical flexibility [32]. The final list of additional categories and subcategories is shown in Table IV. The categories and subcategories added were the influential factors of the identified IT-mediated task coordination mechanisms. For data coding reliability, we employed two coders and checked the agreement between the two coders for all the categories in the template. The inter-coder agreement was 0.75, which is above the acceptable threshold value of 0.7 [36].

[Insert Table IV about here]

Following template coding, we conducted axial coding [33] to achieve our objective of deriving effective IT-mediated task coordination portfolios for the 3 GVTs. The aim in this step is to make connections between categories [2]. We analyzed each case (task) separately to allow its unique patterns to emerge [34]. We then generalized the patterns across cases to look for larger patterns over time [39]. Some relationships were evident from the identified patterns where one code seemed to cause another. For example, the difficulty of having team meeting task coordination in Task B-2 due to the limited common time frame was identified from the following email log:

Since [Europe] has problem with [North America] 10pm, [Europe] 7am, [Asia] 1pm video conference group meetings...how about considering another weeknight…instead of Wednesday night 10pm. Assuming we do get the room every other week for Wednesday night 12:00pm [US] time after class, we should choose some other WEEKNIGHT like Monday, Tuesday or Thursday nights.

In the above email log, we could also identify the relationship between videoconference availability and the utilization of videoconference to mediate team meeting task coordination. In the end, the team did not use videoconference because of its low availability. Instead, they utilized teleconference to mediate their team meeting task coordination.

After identifying the IT-mediated task coordination portfolios and their influencing factors in all 13 tasks, as well as assessing the coordination effectiveness for each task as per the template and axial coding steps explained above, we then derived the match between GVT contextual elements and IT-mediated task coordination portfolio designs. This was done by comparing the influential factors of the portfolios used (e.g., limited common time frame and perceived time constraint), and resultant outcomes of the portfolios across all tasks as discussed in detail next.

RESULTS AND DISCUSSIONS

We now discuss the findings from the cross-case analysis according to the portfolios for each type of task dependence followed by the IT mediation. In Table V, we summarize the coordination mechanisms used for each type of task dependence, the influencing factors, and the outcome (task coordination effectiveness).

[Insert Table V about here]

Pooled Dependence Task Of all the pooled dependence tasks, we found that the tasks of teams A and C (Tasks A-3 and C-3) were effectively coordinated with predetermined standards and plans. However, this was not the case for team B's first pooled dependence task (Task B-1). We explored why this happened.

Based on our analysis we found that, when the geographically dispersed members had prior interactions through team meetings, it reduced the likelihood that they would have different interpretations of the predetermined standard and plan. As individuals develop experience communicating with others, they may develop a knowledge base for those individuals as per channel expansion [40] and dialog theories [17]. Team A used team meetings to coordinate its two team dependence tasks (A-1 and A-2) prior to the pooled task (A-3). The interactions and dialog among members during the team meetings created opportunities for understanding one another's vocabulary, which cultivated implicit coordination. By the time of Task A-3, with their shared understanding, members had similar interpretations of the predetermined standard and plan. Team C also used team meetings to coordinate two team dependence tasks (C-1 and C-2) prior to their pooled task (C-3). Similar to team A, through interactions to better understand one another, team C members had shared meanings and did not experience multiple interpretations of the standard and plan to coordinate their subsequent task, i.e., pooled task.

The next related question is: what should be the optimal task coordination portfolio when there is no previous interaction among all members before a pooled dependence task? We discovered that after the problems in Task B-1, when team B came to its second (pooled) task (Task B-2), immediately after the project manager sent the standard and plan for this task, some members wanted to set up team meetings to gain common understanding and interpretations. Previous studies indicate that organizations often try to remedy inadequate communication by using team meetings as a generic "repair" for every coordination problem [41]. However, our findings show that such group communication is not always effective.

Specifically, in Task B-2, there was a dispute among the members over the team meeting coordination mechanism. While some members questioned the need to inconveniently schedule team meetings to coordinate their low task dependence that did not require such communication, other members were convinced that these meetings were needed to resolve uncertainty due to members' dispersion and get better acquainted with one another. The dispute was escalated when there was unnecessary duplication of work, i.e., two members interviewed the same interviewee. In view of these problems, the project manager decided to email a new standard and plan, as well as actively act as a boundary spanner to vertically coordinate the work of each member which helped to mitigate the situation. Thus, our findings suggest that when there is no previous interaction among all members before a pooled dependence task, predetermined standards and plans need to be complemented by vertical communication to ensure mutual awareness without unnecessary communication (i.e., team meetings) for the low dependence (pooled) task to be effectively coordinated.

Sequential Dependence Task For the sequential dependence task (Task B-3), a combination of predetermined standard, plan, and vertical communication was found to lead to effective

coordination. In this task, the project manager split the team into two subgroups (across locations), selected a leader for each subgroup, and then disseminated rules to the team members via email. Task B-3 required sequencing, i.e., first subgroup members would send their weekly reports to subgroup leaders, then subgroup leaders would summarize the reports and send the summaries to the project manager. To coordinate this sequential work, each subgroup leader disseminated the standard and plan to his subgroup members:

As you may have gathered from the project manager's email, she wants a weekly report from the two sub teams, written by the captain. To put this together, I need to hear from all of you every week regarding companies pursued, schedules, work done.

Besides the predetermined standard and plan, vertical communication was also utilized by subgroup leaders to coordinate this task. For example, when a subgroup member could not submit her progress report on time, the subgroup leader personally coordinated the activity with the particular member via email:

B3, since you have an exam to focus on, I can wait for you to submit your missing information next week...

Thus, our findings suggest that for sequential dependence GVT tasks, predetermined standards and plans are needed to start off the task and subsequent adjustment during sequencing could be made through vertical communication for effective task coordination.

Reciprocal Dependence Task For the reciprocal dependence task (Task A-4), a combination of predetermined standard, plan, vertical and horizontal communications was found to lead to effective coordination. At the beginning of this task, the standard and plan were disseminated to the team members as shown below:

1. 1st draft: Saturday, 15 May, 12 pm Asian time. Asian and North American teams send out each team's proposed solutions (as detailed as possible). Each team then reviews other team's proposals —for input and addition to own team's 2nd draft proposal.
2. 2nd draft: Tuesday, 18 May, 12 pm Asian time. Asian and North American teams send out the proposed solutions of the 2nd draft.
3. Final: Thursday, 20 May, 12 pm Asian time. Asian and North American teams send out proposed final solutions.

Moreover, we observed horizontal coordination between members at the two locations for back and forth iterations of the task. For example, after exchanging their first drafts, the following horizontal communication was noted:

Hi, North American members. We (the Asian members) suggest refocusing the solutions to say why we have made certain recommendations to directly answer the project manager's questions regarding cost effectiveness, customer's needs …

Based on the response from the North American members, both locations standardized the structures of their proposed solutions. Throughout this task, the project manager also exercised

vertical coordination with members from both locations to ensure that the team was on track with respect to the overall timeline of the task. Accordingly, our findings suggest that for reciprocal dependence GVT tasks, predetermined standards and plans are needed to start off the task and subsequent adjustment during back-and-forth iterations could be made through vertical and horizontal communications for effective task coordination.

Team Dependence Task Of all the team dependence tasks in this study, we found that Tasks A-1 and A-5 were effectively coordinated with a combination of predetermined standard and plan, vertical and horizontal communications, and team meeting coordination mechanisms. The same task coordination portfolio was however not effective in Task A-2. We further explored why this happened.

Before the commencement of Task A-2, some members kept stressing about the approaching deadline in their emails and used capital letters when they wanted their remote partners to take immediate action. Due to time constraint in the start of the task itself, even before the project manager sent the standard and plan to be followed in this task, one member created a work plan and sent it to all other members.

… Due to time constraints, I have taken the liberty to assign the people who will interview the FAs and their business managers … members in North America and Asia will have a chance to interview both FAs and business managers so as to obtain a better view of their jobs. Here is the assignment …

When the project manager sent new lists of interviewees, Team A wanted to coordinate their interview distribution task through a team meeting. However, perceiving high time constraint, some members preferred to spend more time working on the actual task than coordinating the task via a team meeting; thus creating doubts about the necessity of having the team meeting. Consequently, the scheduling of the team meeting in this task (Task A-2) was more difficult than in their two other team dependence tasks (Tasks A-1 and A-5). Some members refused to "show up" in several meetings with reasons such as being too busy completing their parts of the work, and having no time for the meetings. As a result, there was a misunderstanding about who should interview particular respondents which resulted in duplicate work assignments.

Interestingly, although Team C also faced scheduling difficulties for its team meetings that stemmed from members' limited common time frame (i.e., members were dispersed in 3 continents with only one hour common time frame as compared to team A's members that were dispersed in 2 continents with seven hours common time frame), coordination of Tasks C-1, C-2, C-4, and C-5 were effective. Team C utilized a combination of predetermined standard and plan, vertical and horizontal communications, and *structured* team meetings (different from team meetings in the other teams). In contrast to the other teams, team C structured its teleconference meetings by posting meeting agendas prior to each meeting and meeting minutes after each meeting as a work plan to be adhered to until their next meeting. With the meeting agendas, there were several horizontal communications between pairs of members prior to the team meeting, which in turn reduced the time needed to reach a consensus on how the team dependence activities should be coordinated. Moreover, with the meeting minutes acting as a work plan to be

followed by all members until their next meeting, redundancy and unnecessary duplication of efforts was avoided.

The findings from Team A suggest that for GVT team dependence tasks with *relatively higher common time frame* and *relatively lower time constraints,* predetermined standards, plans, vertical and horizontal communications can adequately be complemented with team meetings for effective task coordination. On the other hand, the findings from Team C suggest that for GVT team dependence tasks with *relatively lower common time frame* and *relatively lower time constraints*, predetermined standards, plans, vertical and horizontal communications should be complemented with structured team meetings for effective task coordination.

The remaining conditions (i.e., team dependence tasks with relatively low/high members' common time frame and perceived relatively high time constraints) either did not appear in our study or were not effectively coordinated. Hence we did not venture any recommendations for such tasks. Besides matching GVT characteristics (task dependence, common time frame, and time pressure) and task coordination portfolios, we also investigated the match between task coordination mechanisms and IT mediation which will be discussed in the next subsection.

IT Mediation *Predetermined standards and plans* in Tasks A-1 to A-5, and Task B-3 were altogether disseminated via email and uploaded onto an online bulletin board. Email was chosen because all members were familiar with receiving and reading email messages; thus lowering their cognitive effort to receive and read the standard and plan messages. Online bulletin board was chosen as a backup storage for the predetermined standard and plan because of its ease of information storage and retrieval.

In Tasks C-1 to C-5, the predetermined standards and plans were uploaded onto the online bulletin board; whereas in Tasks B-1 and B-2, they were solely disseminated via email. Email dissemination without bulletin board backup created problems in Task B-1: some members accidentally deleted the email message regarding the standards and plans, and asked other members to forward them the email message, which resulted in redundant work. This finding signaled the unsuitability of using email alone to mediate the predetermined standard and plan task coordination mechanism. It suggests that a repository such as an online bulletin board is appropriate to mediate predetermined standard and plan task coordination mechanism.

Vertical and horizontal communications in our case data (Tasks A-1, A-2, A-4, A-5, B-2, B-3, C-1, C-2, C-4, C-5) were supported by asynchronous communication technology (i.e., email). The key reason for choosing email was because members were familiar with email communications and thus, did not need to exercise much cognitive effort as shown in the interview transcript below:

individual emails suit the situation … every member has experience using it (e-mail) and finds it comfortably easy.

Although it seems that asynchronous communication technology (email) could mediate vertical and horizontal communications, we could not rule out synchronous communication technology (e.g., telephone) as being optimal in supporting vertical and horizontal communications. In fact,

we observed that the immediate replies to email-mediated vertical and horizontal communications coordination mechanisms mimicked synchronous communication. Thus both synchronous and asynchronous communication technologies could be appropriate to mediate horizontal and vertical communication coordination mechanisms.

*Team meeting*s in Task A-1 and the first half of Task A-2 were mediated by ICQ. Afterwards (second half of Task A-2 and Task A-5), Team A utilized teleconference to mediate its team meetings. The reason for shifting from ICQ to teleconference was due to the lower communication ambiguity in teleconference meetings as compared to ICQ meetings, as claimed by a member:

Teleconference is very good for delegating tasks and planning the next course of action and speaking is definitely less ambiguous than typing.

In Team B, videoconference was originally intended to mediate team meetings; however due to its low *availability* (there was only one videoconference room in each location which had to be shared with the other teams), teleconference was chosen to support the team meetings. Besides the availability constraint, another reason for shifting from videoconference to teleconference was because the low physiological arousal during teleconferencing made members focus more on the task on hand. A member wrote in his lesson learned paper:

For a group meeting, teleconferencing often works just as well as video conferencing. While it is exciting to be able to see the rest of our team, I don't think that the technology (video conferencing) makes us more focused (on the task).

Although ICQ had similar low physiological arousal as teleconference, it was not considered as an optimal alternative for videoconferencing because of the possibility of experiencing high communication ambiguity. Hence, this suggests that teleconference is suitable to mediate the team meeting task coordination mechanism.

In Task C-1, team C had a videoconference meeting which was complemented by the use of the online bulletin board to store the meeting agenda and minutes. Afterwards (Tasks C-2, C-4, C-5), team C utilized teleconference which was still complemented by online bulletin board for effective task coordination. This suggests that teleconference complemented by a repository is suitable for structured team meeting coordination.

Summary of the Findings Table VI summarizes our findings on the effectiveness of different IT-mediated task coordination portfolios abstracted from Table V.

[Insert Table VI about here]

Our findings suggested two sets of fit: 1) between GVT characteristics (i.e., task dependence, members' common time frame, perceived time constraint) and task coordination portfolios, and 2) between task coordination mechanisms and IT. It appeared that if there was a misfit in either one, task coordination became ineffective. The optimal IT-mediated task coordination portfolios derived from our findings in Table VI are shown in Table VII, i.e., these for which coordination

was effective. It is important to note here that not all conditions appear in this table as they either did not occur in our study (e.g., reciprocal dependence tasks with relatively low members' common time frame and perceived relatively high time constraints) or were not effectively coordinated (e.g., team dependence tasks with relatively high members' common time frame and perceived relatively high time constraints).

[Insert Table VII about here]

IMPLICATIONS AND CONTRIBUTIONS

Contributions to Research When organizations assemble geographically dispersed members with the required expertise to obtain potential benefits [3], it is not always possible to select people with shared work experience required for implicit coordination or wait for the shared experience to develop. Thus although both implicit and explicit coordination would have roles to play in GVT coordination, understanding how to perform explicit coordination in GVT based on the nature of the team and task is important but still absent in the literature.

This study extends previous theory on effective task coordination from collocated teams to GVT as follows. First, for pooled and sequential dependence tasks, this paper suggests the use of vertical communication coordination mechanism besides standards and plans. Second, for team dependence tasks, this paper distinguishes between team meetings and structured team meetings. Structured team meetings are needed when GVT members have a limited common time frame. Third, besides the type of task dependence, we found two other factors which are important for designing the GVT task coordination portfolio, i.e., members' common time frame and perceived time constraint. When GVT members have low common time frame or perceive high time constraint, but need to coordinate their task with the team meeting task coordination mechanism, a structured team meeting may be necessary for effective task coordination.

Our study also extends predictions from dialogue theory for GVT task coordination. In collocated teams, researchers proposed to match task coordination portfolios to the degree of the team's task dependence for effective coordination (e.g., [14]-[16]). Dialogue researchers however argued that this recipe for effective task coordination may constrain team members' desire for dialogue and their capacity to produce it. According to the action theory of dialogue, members should become conscious of and share with the whole group the expectations about what will be exchanged and a code for the production and comprehension of the behavior through which the exchange is enacted [26]. This research aimed to reconcile the suggestions from the two theories by investigating these aspects in the GVTs studied.

While the overall findings showed that there must be some form of dialogue in GVT to attain effective task coordination, the modes of dialogue differed depending on the types of task dependence. In particular, vertical communication mode is effective in pooled and sequential tasks, vertical and horizontal communication modes are effective in reciprocal tasks, and vertical, horizontal, and team communication modes are effective in team dependence tasks. Planning a dialogue with the entire team (i.e., team meeting) to coordinate a relatively low task dependency (i.e., pooled task) will result in ineffective task coordination as members may question its need and refuse to participate.

Since GVT members rely extensively on IT to communicate, task coordination effectiveness may also depend on the IT used to mediate their task coordination. Thus, besides matching task coordination portfolio designs to GVT contextual elements, the paper also highlights the appropriate types of IT to support the different task coordination mechanisms (i.e., predetermined standards and plans, vertical and horizontal communications, and team meetings). Previous computer-mediated-communication (CMC) studies have informed us about how IT can be chosen and appropriated for effective communication in general (e.g., [30], [42]-[45] rather than specifically for task coordination. In a distributed team context, Majchrzak et al. [46] examined how IT can develop individual's collaboration know-how. Adding to previous CMC studies, this study focuses on how IT can be used for effective GVT task coordination, which is important to their project success.

Further, this study extends media naturalness theory to investigate the optimal types of IT to support different GVT task coordination mechanisms. Once standards and plans are set up, members need to be able to retrieve and follow them. We found that a repository such as an online bulletin board was suitable for storing the predetermined standards and plans. Although a more natural asynchronous communication technology, such as email, can also store task coordination information, the information may get deleted or overlooked. On the other hand, during vertical and horizontal communication, a supervisor and subordinate or peers need to repeatedly communicate to coordinate the task. We found that communication technology that members *perceive* to require low cognitive effort could be used to support their vertical and horizontal communication coordination mechanisms effectively. Although synchronous media have relatively higher naturalness than asynchronous media, the frequent use of asynchronous media (i.e., email) with compensatory adaptation behaviour (such as constructing better structured email messages to minimize communication ambiguity and immediately replying to emails to mimic the synchronicity of synchronous communication) led to effective task coordination.

Media naturalness theory indeed cautions that a user may expend effort to adapt to the impediments presented in a medium [19]. While GVT members could easily adapt to a less natural asynchronous medium during their vertical and horizontal coordination, the same may not be true during the simultaneous multilateral interactions in their team meeting coordination. For the team meeting task coordination mechanism, we found that because the most natural medium (i.e., videoconference) had low availability, GVTs in our study decided to utilize teleconference. Another synchronous IT that was highly available to the GVTs, i.e., ICQ, was not considered as an optimal alternative for videoconferencing because it is less natural than teleconference. Therefore our findings are by and large consistent with media naturalness theory in the presence of constraints and serve to extend its applicability to GVT task coordination.

Implications for Practice Besides contributing to research, this study offers several preliminary insights for GVT practitioners, the most salient being the suggestion of suitable task coordination portfolios for different GVT contexts. Here we elaborate on the implications in terms of member dispersion and the use of IT.

In GVT with lower member dispersion, for *team dependent tasks* with less stringent time constraints, a combination of predetermined standards and plans, vertical and horizontal communications, and team meetings are suitable to coordinate their task. However when meeting time becomes a scarce resource due to high member dispersion, GVTs have to structure their team meetings by posting minutes as work plans after each meeting as well as meeting agendas before each meeting. While this approach sounds simple enough, it is often not practiced. Riopelle et al. [47] described a product development GVT whose members were dispersed in Japan and the US (high dispersion). Their teleconferences turned out to be ineffective since the meeting arrangements were not made in advance. With limited common time frame, structured meetings are useful to maximize precious team meeting time.

As a consequence of member dispersion, we found that coordinating the *pooled and sequential dependence tasks* of GVTs with only predetermined standards and plans may result in under-coordination. Members in distributed locations might interpret the impersonally specified task coordination information differently, leading to ineffective task coordination. Ovaska et al. [48] observed multi-site programmers who relied on a given software architecture to coordinate their coding work before aggregating their codes. Without knowing about remote team members' work progress, the programmers did not realize the lack of common understanding of the software architecture until it was too late [48]. While it is difficult to build shared awareness if dispersed members do not interact, GVT project managers should also be wary when members push for more team meetings to gain team awareness for their relatively low degree of task dependency. Such over-coordination is time-consuming and costly and might negate some of the savings possible through GVT. Our study suggests that vertical communication to supplement predetermined plans and schedules could alleviate such problems. Specifically, GVT project managers can act as boundary spanners to vertically coordinate the work of members and at the same time convey team progress information to distributed members. As for *reciprocal dependence tasks,* our finding is similar to the previous studies on collocated teams in that they should be coordinated with predetermined standards and plans as well as vertical and horizontal coordination mechanisms.

Another important insight is with respect to the suitable IT to support each task coordination mechanism. Since it is important for GVT members to be able to quickly retrieve the predetermined standards and plans, the project manager should store them in an online repository. Even if they are sent via email to all members, backup storage in an online repository is necessary as members may overlook or accidentally delete the email message containing the work standard and plan leading to ineffective coordination and possible conflict situations [49]. Moreover, while it may be easier for two people to adapt to any available communication technology to support their vertical or horizontal communication mechanisms, this may not be the case for team meeting mechanisms that involve all or a significant subset of GVT members. Since the optimal IT to support team meeting task coordination is the one with the highest degree of naturalness, e.g., videoconference, organizations should ensure that this particular IT is available in all locations where the GVT members work. While desktop-videoconference tools are likely to be available in employees' personal computers, a more sophisticated and dedicated videoconference tool may have limited availability due to the relatively higher cost. Alternatively other synchronous communication technology, such as teleconference, may have to compensate if such facilities are unavailable. GVT project managers must be aware of the

tradeoff between facilitating team meetings with the most natural communication technology to lower communication ambiguity as compared to less natural communication technology that lowers physiological arousal to encourage task focused discussions.

Overall, the findings of this study have implications for GVT project managers and members as professional communicators. As key actors in task coordination, GVT project managers can send predetermined standards and plans, engage in vertical communication coordination, and arrange for team meeting coordination. Particularly this study emphasizes their role as team meeting facilitators for high task dependence (i.e., team dependence task) and as boundary spanners for lower task dependence, especially pooled dependence tasks. The avoidance of redundant or duplicate work by GVT members depends on the project managers' active involvement to set up and store plans and vertically coordinate with geographically dispersed members to ensure they have the same understanding of the task and are working on what they are supposed to. For GVT members their skills need to be developed to adapt less-natural asynchronous media (i.e., email) towards effective horizontal coordination. This includes the ability to construct structured email messages to minimize communication ambiguity and to develop the norm of immediately replying to the emails (subject to time difference constraints) in order to mimic synchronous communication. However, in view of potential adaptation problems, use of synchronous media cannot be avoided and GVT members may have to resort to more available media such as teleconference in mediating their horizontal coordination.

Limitations and Future Work The above findings should be viewed in the light of the limitations of the study. First, the GVTs under study had stable memberships and worked on projects of five-month duration, though this is of a longer duration than typical student GVT studies. Further research would be useful for validating the findings in GVTs with fluid membership and those working on projects of longer duration where implicit coordination may become dominant. Second, the study focused on the interdependence characteristic of the members' work. Although task dependence is the crux of task coordination [28], future research can extend the study to include other task characteristics such as complexity. Third, our discussion on matching GVT contingencies to task coordination portfolios is based on the characteristics of the tasks in the three GVTs under study. The results and implications presented in this paper should thus be considered as preliminary. In future research, it would be useful to increase the sample size and quantitatively validate the fit propositions in order to test the generalizability of the findings. A survey could be conducted for this purpose. Finally, GVTs in different domains such as software development could be investigated to explore the generalizability of our findings to team activities other than the market analysis or consultancy tasks in our study.

CONCLUSION

A mistake that can prove costly for organizations is the failure to create coordination mechanisms that could effectively integrate the expertise and skills of dispersed employees in GVTs. The technological advancements of recent years might not guarantee the benefits obtainable from GVTs without a clear understanding of how to design effective GVT task coordination. This study contributes to designing appropriate task coordination mechanisms in GVT contexts for effective coordination [12], [13]; especially in GVTs where shared work

experience or member familiarity cannot be assumed. Through conducting an in-depth study of 13 tasks, this study found suitable task coordination portfolio designs for combinations of GVT contextual elements in the form of task dependence, members' common time frame, and perceived time constraints. Moreover, this study highlighted appropriate IT to support each task coordination mechanism. Besides contributing to research, this study offers guidelines for organizations and professional communicators to address task coordination challenges and realize the benefits of GVT.

REFERENCES

[1] C. D. Cramton, "The mutual knowledge problem and its consequences for dispersed collaboration," *Organization Science*, vol. 12, no. 3, pp. 346-371, 2001.

[2] M.L. Maznevski and K.M. Chudoba, "Bridging space over time: Global virtual team dynamics and effectiveness," *Organization Science*, vol. 11, no. 5, pp. 473-492, 2000.

[3] M. Ahuja, F. Bélanger, and M.B. Watson-Manheim, "Contemporary virtual environments," *The Database for Advances in Information Systems*, vol. 35, no.1, pp. 37-39, 2004.

[4] G.W. Wittenbaum, S.I. Vaughan, and G. Stasser, "Coordination in task-performing groups," in *Theory and Research on Small Groups*, R. S. Tindale, Ed. New York: Plenum Press, 1998, pp. 177-204.

[5] J. Cummings and S. Kiesler, "Coordination and success in multidisciplinary scientific collaborations," in *Proceedings of 24th International Conference on Information Systems*, 2003, pp. 296-302.

[6] P. Hinds and M. Mortensen, "Understanding antecedents to conflict in geographically distributed research and development teams," in *Proceedings of 23rd International Conference on Information Systems*, 2002, pp. 415-424.

[7] I.D. Steiner, *Group Process and Productivity*. New York: Academic Press, 1972.

[8] J.A. Espinosa, S. A. Slaughter, R.E. Kraut, R. E., and J.D. Herbsleb, "Team knowledge and coordination in geographically distributed software development," *Journal of Management Information Systems*, vol. 24, no. 1, pp. 135-169, 2007.

[9] J.A. Espinosa, S. A. Slaughter, R.E. Kraut, R. E., and J.D. Herbsleb, "Familiarity, complexity, and team performance in geographically distributed software development," *Organization Science*, vol. 18, no. 4, pp. 613-630, 2007.

[10] S. Faraj and L. Sproull, "Coordinating expertise in software development teams," *Management Science*, vol. 46, no. 12, pp. 1554-1568, 2000.

[11] J.D. Herbsleb and R.E. Grinter, "Architectures, coordination and distance: Conway's law and beyond," *IEEE Software*, vol. 16, no. 5, pp. 63-70, 1999.

[12] P. Hinds and C. McGrath, "Structures that work: Social structure, work structure and coordination ease in geographically distributed teams," in *Proceedings of the Conference on Computer Supported Cooperative Work*, 2006, pp. 343-352.

[13] A.P. Massey, M.M. Montoya-Weiss, and Y-T. Hung, "Because time matters: Temporal coordination in global virtual project teams," *Journal of Management Information Systems*, vol. 19, no. 4, pp. 129-155, 2003.

[14] H.P. Andres and R.W. Zmud, "A contingency approach to software project coordination," *Journal of Management Information Systems*, vol. 18, no. 3, pp. 41-70, 2001/2002.

[15] J.D. Thompson, *Organization in Action*. New York: Mc Graw-Hill, 1967.

[16] A.H. Van de Ven, A.L. Delbecq, and R. Koenig, "Determinants of coordination modes

within organizations," *American Sociological Review*, vol. 41, no. 2, pp. 332-338, 1976.
[17] W.N. Isaacs, "Towards an action theory of dialogue," *International Journal of Public Administration*, vol. 24, no. 7-8, pp. 709-748, 2001.
[18] N. Kock, "Media richness or media naturalness? The evolution of our biological communication apparatus and its influence on our behavior toward e-communication tools," *IEEE Transactions on Professional Communication*, vol. 48, no. 2, pp. 117-130, 2005.
[19] N. Kock, "The psychobiological model: Towards a new theory of computer-mediated communication based on Darwinian evolution," *Organization Science*, vol. 15, no. 3, pp. 327-348, 2004.
[20] R.E. Kraut and L.A. Streeter, "Coordination in software development," *Communications of the Association for Computing Machinery*, vol. 38, no. 3, pp. 69–81, 1995.
[21] A. Grandori, "An organizational assessment of interfirm coordination modes," *Organization Studies*, vol. 18, no. 6, pp. 897-925, 1997.
[22] K. Kumar and H.G. van Dissel, "Sustainable collaboration: Managing conflict and cooperation in inter-organizational systems," *Management Information Systems Quarterly*, vol. 20, no. 3, pp. 279-300, 1996.
[23] R. Sabherwal, "The evolution of coordination in outsourced software development projects: A comparison of client and vendor perspectives," *Information and Organization*, vol. 13, no. 3, pp. 153-202, 2003.
[24] S. Nidumolu, "The effect of coordination and uncertainty on software project performance: Residual performance risk as an intervening variable," *Information Systems Research*, vol. 6, no. 3, pp. 191-219, 1995.
[25] J.H. Gittell, "Coordinating mechanisms in care provider groups: Relational coordination as a mediator and input uncertainty as a moderator of performance effects," *Management Science*, vol. 48, no. 11, pp. 1408-1426, 2002.
[26] A. Donnellon, B. Gray, and M.G. Bougon, "Communication, Meaning, and Organized Action," *Administrative Science Quarterly*, vol. 31, no. 1, pp. 43-55, 1986.
[27] W. Huang, K.K. Wei, B. Bostrom, L.H. Lim, and R.T. Watson, "Supporting distributed team-building using GSS: A dialogue theory-based framework," in *Proceedings of 31st Annual Hawaii International Conference on System Sciences*, 1998, pp. 98-108.
[28] T.W. Malone and K. Crowston, "The interdisciplinary study of coordination," *ACM Computing Surveys*, vol. 26, no.1, pp. 87-119, 1994.
[29] P.A. Bernstein and U. Dayal, "An overview of repository technology," in *Proceedings of 20th International Conference on Very Large Databases*, 1994, pp. 705–713.
[30] R.M. Fuller and A.R. Dennis, "Does fit matter? The impact of task-technology fit on team performance for repeated tasks," *Information Systems Research*, vol. 20, no. 1, pp. 2-17, 2009.
[31] L. Dube and G. Pare, "Rigor in IS positivist case research," *Management Information Systems Quarterly*, vol. 27, no. 4, pp. 597-635, 2003.
[32] N. King, "Template analysis," in *Qualitative Methods and Analysis in Organizational Research: A Practical Guide*, G. Symon and C. Cassell, Ed. Thousand Oaks, CA: Sage, pp. 118-134, 1998.
[33] A.L. Strauss and J. Corbin, *Basics of Qualitative Research: Grounded Theory Procedures and Techniques.* Newbury Park, CA: Sage, 1990.
[34] K.M. Eisenhardt, "Building theories from case study research," *Academy of Management*

Review, vol. 14, no. 4, pp. 532-550, 1989.
[35] A. Powell, G. Piccoli, and B. Ives, "Virtual teams: A review of current literature and direction for future research," *The Database for Advance in Information Systems*, vol. 35, no. 1, pp. 6-36, 2004.
[36] L.R. James, R.G. Demaree, and G. Wolf, "Estimating within-group interrater reliability with and without response bias," *Journal of Applied Psychology*, vol. 69, no. 1, pp. 85-98, 1984.
[37] L. Benson, L.R. Beach, "The effects of time constraints on the prechoice screening of decision options," *Organization Behavior and Human Decision Processes*, vol. 67, no. 2, pp. 222-228, 1996.
[38] H. Rastegary and F.J. Landy, "The interactions among time urgency, uncertainty and time pressure," in *Time Pressure and Stress in Human Judgement and Decision Making*, O. Svenson and A.J. Maule, Ed. New York: Plenum, 1993, pp. 217-239.
[39] R.K. Yin. *Case Study Research: Design and Methods*. Newbury Park: Sage, 2003.
[40] J.R. Carlson and R.W. Zmud, "Channel expansion theory and the experiential nature of media richness perceptions," *Academy of Management Journal*, vol. 42, no. 2, pp. 153-170, 1999.
[41] C. Heath and N. Staudenmayer, "Coordination neglect: How lay theories of organizing complicate coordination in organizations," *Research in Organizational Behavior*, vol. 22, pp. 153-191, 2000.
[42] A.R. Dennis, B. H. Wixom, and R. J. Vandenberg, "Understanding fit and appropriation effects in group support systems via meta-analysis," *Management Information Systems Quarterly*, vol. 25, no. 2, pp. 167–193, 2001.
[43] W.W. Huang and K.K. Wei, "An empirical investigation of the effects of group support system (GSS) and task type on group interactions from an influence perspective," *Journal of Management Information Systems*, vol. 17, no. 2, pp. 181-206, 2000.
[44] A. Majchrzak, R.E. Rice, A. Malhotra, N. King, and S. Ba, "Technology adaptation: The case of a computer-supported inter-organizational virtual team," *Management Information Systems Quarterly*, vol. 24, no. 4, pp. 569-600, 2000.
[45] I. Zigurs and B.K. Buckland, "A theory of task/technology fit and group support systems effectiveness," *Management Information Systems Quarterly*, vol. 22, no. 3, pp. 313-334, 1998.
[46] A. Majchrzak, A. Malhotra, and R. John, "Perceived individual collaboration know-how development through IT-enabled contextualization: Evidence from distributed teams," *Information Systems Research*, vol. 16, no. 1, pp. 9-27, 2005.
[47] K. Riopelle, J.C. Gluesing, T.C. Alcordo, M.L. Baba, D. Britt, W. McKether, L. Monplaisir, H.H. Ratner, and K.H. Wagner, "Context, task, and the evolution of technology use," in *Virtual Teams that Work: Creating Conditions for Virtual Team Effectiveness*, C.B. Gibson and S.G. Cohen, Ed. San Francisco: Jossey-Bass, 2003, pp. 239-264.
[48] P. Ovaska, M. Rossi, and P. Marttiin, "Architecture as a coordination tool in multi-site software development," *Software Process Improvement Practice*, vol. 8, no. 4, pp. 233-247, 2003.
[49] A. Kankanhalli, B.C.Y. Tan, and K.K. Wei, "Conflict and Performance in Global Virtual Teams," *Journal of Management Information Systems*, vol. 23, no. 3, pp. 237-274, 2007.

Fig. 1. Typology of Task Dependence

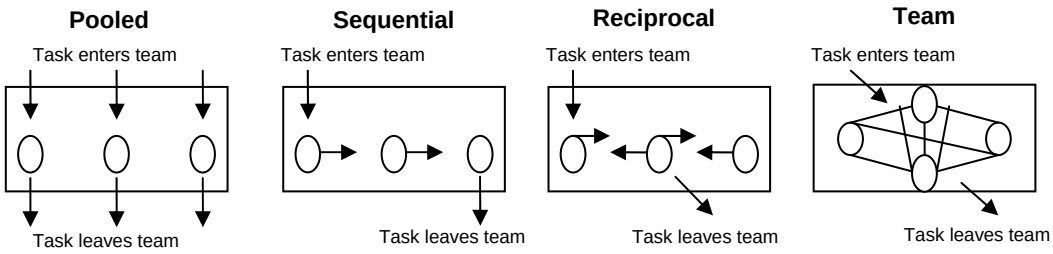

Fig. 2. Matching Task Dependence and Task Coordination Portfolios in Collocated Teams

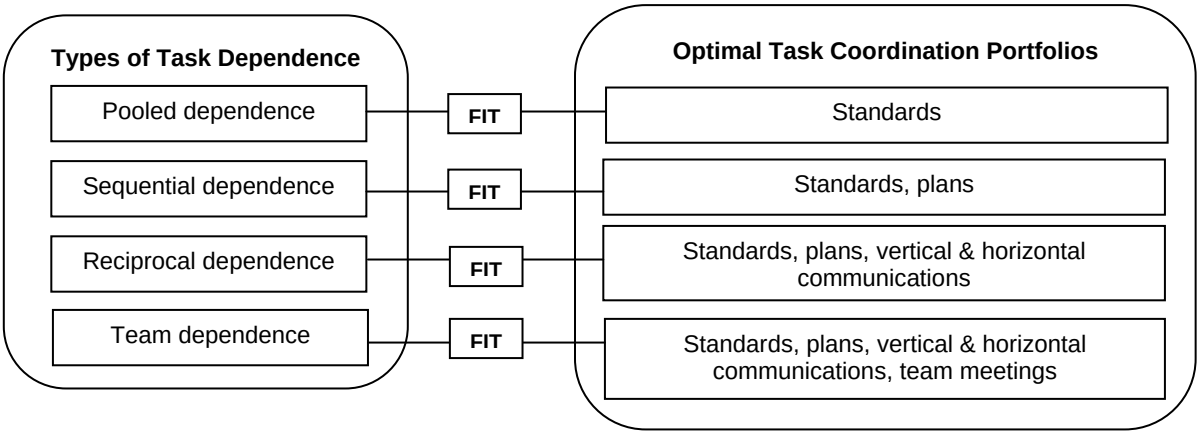

Table I. Team and Task Characteristics

	Team A	Team B	Team C
Team size	7 members	11 members	9 members
Member dispersion	3 in Asia, 4 in North America *(7 hours common time frame)*	2 in Asia, 5 in North America, 4 in Europe *(1 hour common time frame)*	2 in Asia, 4 in North America, 3 in Europe *(1 hour common time frame)*
Sponsor	Global computer company	Global consulting company	Global telecoms company
Project objective	Re-engineer financial analyst business unit within the sponsor company for a more effective structure	Collect information about risk assessment and management in different industries using a pre-designed questionnaire	Identify emerging mobile applications, charging mechanisms, and underlying technologies from Internet Service Providers (ISPs)
Tasks (type of dependence based on their inherent property)	A-1 Create questionnaire **(team dependence)** A-2 Distribute interview job **(team dependence)** A-3 Interview financial analysts, and business admin in assigned locations **(pooled dependence)** A-4 Identify problems and generate solutions **(team dependence*)** * later changed to **reciprocal** under time constraint A-5 Write final report (**team dependence**)	B-1 Identify companies in the suggested industry sectors in each location (**pooled dependence**) B-2 Interview and administer risk assessment survey in each location (**pooled dependence**) B-3 Weekly report writing of interview progress* (**sequential dependence**) * added due to conflict during previous task	C-1 Discuss the type of mobile application to focus on and create questionnaire and interview questions (**team dependence**) C-2 Distribute interview job (**team dependence**) C-3 Interview ISPs and send out surveys (**pooled dependence**) C-4 Analyze data and generate ideas (**team dependence**) C-5 Write final report (**team dependence**)

Table II. Data Sources

Data Sources	Team A	Team B	Team C
Synch. Communication Logs	▪ Transcriptions of 4 teleconference meetings ▪ Logs of 3 ICQ meetings * videoconferencing not used	▪ Transcriptions of 6 teleconference meetings * videoconferencing and ICQ not used	▪ Transcriptions of 3 teleconference meetings ▪ Minutes of 7 teleconference and 3 videoconference meetings * ICQ not used
Asynch. Logs	▪ 374 emails	▪ 437 emails	▪ 249 emails
Repository logs	▪ 54 bulletin board postings	▪ 19 bulletin board postings	▪ 94 bulletin board postings
Documentation	▪ Project descriptions, members' lessons learned papers		

Table III. Original Template

Categories and Sub-Categories	Definition	Examples of Evidence
Types of Task Dependence		
Pooled Dependence	Each member's part is independently completed, followed by aggregation	In Tasks B-1 and B-2 (the first and second tasks of Team B), members were provided with a pre-designed risk assessment questionnaire and a list of industries to investigate. Each member could independently identify the target companies in the suggested industry sectors and interview the executives before aggregating the results. In Tasks A-3 and C-3, members could independently conduct their interviews before aggregating the results.
Sequential Dependence	One or more members complete their parts before the other member(s) can begin	During the course of the project, team B's project manager split the team into two subgroups, and added another task (Task B-3) to each subgroup, which was to write weekly reports about their interview progress. Subgroup members needed to send their weekly reports to subgroup leaders who would then summarize the reports and send the summaries to the project manager.
Reciprocal Dependence	Works flow in a "back and forth" manner between members	In Task A-4, members in Asia and North America sent their proposed solutions back-and-forth to each other until both continents reached a consensus.
Team Dependence	All members concurrently diagnose, problem-solve, and collaborate as a group to deal with the task. There is no measurable temporal lapse in the flow of work among members	Tasks A-1, A-2, and A-5 (i.e., questionnaire creation, distributing interview jobs, and writing the recommendation report) required input from all members. All members needed to brainstorm together to design the questionnaire, decide on who should interview whom, and generate the recommendation proposal. Tasks C-1, C-2, C-4, and C-5 (i.e., brainstorming the type of applications and generating the questionnaire, distributing interview jobs, analyzing the data, and writing the final report) required input from all members. To accomplish the tasks, members had to concurrently diagnose, problem-solve and collaborate as a group.
Task Coordination Mechanisms		
Predetermined standards and plans	Written communication explicitly defining what each member is expected to accomplish prior to the commencement of the task	Below is an example of standard and plan that was sent to team A by **email** prior to commencement of Task A-4: *1. 1st draft: Saturday, 15 May, 12 pm Asian time. Asian and North American teams send out each team's proposed solutions (as detailed as possible). Each team then reviews other team's proposals —for input and addition to own team's 2nd draft proposal.* *2. 2nd draft: Tuesday, 18 May, 12 pm Asian time. Asian and North American teams send out the proposed solutions of the 2nd draft.* *3. Final: Thursday, 20 May, 12 pm Asian time. Asian and North American teams send out proposed final solutions.*
Vertical communications	A project manager or a team leader made mutual adjustments while	The use of *vertical task coordination* by Team B's project manager during Task B-2 is evident in his **email** message: *I need to know which of you will be contacting which of the contacts ... If you are already on holiday or gone for the weekend I will just assign them according to the relevant industries*

	members are working on the task	
Horizontal communications	A team member made mutual adjustments while his/her teammates are working on the task	The use of *horizontal coordination* among peers during Task A-1 is evident in the following **email** message of one member: *Although A1 (Member 1 in Team A) started this first, maybe it is a good idea to continue with the questionnaire that A2 sent to avoid confusion later when the questionnaire for managers is needed.*
Team meetings	All or a significant subset of members interact to coordinate the task	Below is an extract from Team C's **teleconference** meeting transcripts illustrating the use of this coordination mechanism in Task C-1: *C1 (Member 1 in Team C): … for tomorrow, do we want to give the project manager a full application or a narrowed down one?* *C2: A full application, I think.* *C3: I agree.* *C4: I think we should give him a full application and if he wants to cut it … just let him do it* *C5: Anyway he has to cut it otherwise, it is too long for us.* *C6: When we talk to the ISP, do we ask the ISP what the applications are?* *C7: I think … we ask the ISPs which applications they think are upcoming …* *C3: At first we need to ask what they think the best application is. We'll make a comment after that.* *C8: Right now I think all the top applications are wireless e-commerce, video, web pages …* *C9: We can see other applications also by reading about them. I think it is good to just make a summary …*
IT Mediation	Besides the task coordination mechanisms, we also identified the IT used to support the mechanisms (email, bulletin board, teleconference, videoconference, or ICQ) as highlighted in bold in the task coordination mechanism examples above.	
Task Coordination Effectiveness	We identified the coordination effectiveness of each task when it had ended. Task coordination was considered ineffective when there was extra work, unnecessary duplicate work or some parts of a task not done.	Coordination of Task A-2 was ineffective due to the unnecessary *duplication of work.* Two members interviewed the same person as evidenced in the following email log: *Have I missed an email on this? Isn't A3 (Member 3 in Team A) supposed to interview Carol?* Ineffective coordination also occurred in Task B-1. The predetermined standard and plan emailed to the team read as follows: *Here are some of the things that I will need from each of you by Tuesday.* *… List industries which are local to your region. List companies in these industries which are local. List any companies in which you personally know an employee. Format: Name (of the employee), How do you know them …* Misinterpreting the work plan, members in one location did *extra work*. Instead of performing the work individually as specified, they *redundantly* discussed completing the work together, as shown in the email log below: *Shall we meet one of these days? … We can discuss the company lists …* We did not find members leaving some parts of the task undone in any of team C's tasks. Task coordination effectiveness was apparent in a member's lesson learned paper: *… my team has been working effectively and harmoniously throughout …*

Table IV. Additions for Final Template

Categories and Sub-Categories	Definition	Examples of Evidence
Influential Factors of the Task Coordination Mechanism (GVT contextual elements)		
Perceived time constraint	Perceived difference between the amount of available and required time to complete the task [37], [38]	When a member in Team A created a work plan and **email**ed it to her teammates before the start of Task A-2, she wrote: *… Due to time constraints, I have taken the liberty to assign the people who will interview the FAs and their business managers … members in North America and Asia will have a chance to interview both FAs and business managers so as to obtain a better view of their jobs. Here is the assignment …*
Common time frame	The extent to which team members' work hours overlap	Team B was restricted in its use of the **teleconference**-mediated team meeting mechanism during Task B-2 due to only 1 hour common work time among their 3 locations. A member wrote in his lesson learnt paper: *Being dispersed across 3 continents, we did not have much common time for team meetings.*
Influential Factors of the IT Mediation		
IT availability	The physical availability of the IT in all locations	When Team B had team meetings, they decided to have **teleconference** meetings instead of **videoconference** meetings because there was only one videoconference facility in each location which had to be shared with the other teams. A member commented: *We have relied primarily on teleconferencing since videoconferencing was hard to schedule due to unavailability*
Cognitive effort	The amount of mental activity involved in a communication interaction	The main reason of choosing **email** to support vertical communication mechanism in Task B-2 was because all members were familiar with email communications and thus, did not need to exercise much cognitive effort, as shown in the interview transcript below: *… individual emails suit the situation … every member has experience using it (email) and finds it comfortably easy.*
Ease of information storage and retrieval	Ease of aggregation, structuring, and evaluation of information	Besides sent via **email**, the predetermined work plan for Task A-2 was also uploaded into online **bulletin board**. A member commented: *(Email) good for record keeping…(Yet) emails become voluminously unmanageable and disorganized.* *(Online) bulletin board can store documents (and) is easy to use (for retrieving the documents).*
Communication ambiguity	The probability of misinterpreting the communicative cues	In the second-half of Task A-2, the team shifted from **ICQ** to **teleconference** meetings. A member commented: *Teleconference is very good for delegating tasks and planning next course of action and speaking is definitely less ambiguous than typing.*
Physiological arousal	The excitement resulting from the use of an IT which could be associated with a lower degree of communication focus on the task	In Team C, **teleconference** was utilized to mediate team meeting task coordination mechanism because teleconferencing led to relatively low physiological arousal as compared to **videoconfere**ncing. A member wrote in his lesson learned paper: *For group meeting, teleconferencing often works just as well as video conferencing. While it is exciting to be able to see the rest of our team, I don't think that the technology (video conferencing) makes us more focused (on the task).*

Table V. Cross-Case Analysis Results

Task Dependence	**Pooled**				**Sequential**	**Reciprocal**	**Team**			
Tasks	**A-3**	**B-1**	**B-2**	**C-3**	**B-3**	**A-4**	**A-1**	**A-2**	**A-5**	**C-1, C-2, C-4, C-5**
Task Coord. Portfolio ***(IT Mediation)***	Predetermined standard and plan *(disseminated via email and stored on online bulletin board)*	Predetermined standard and plan *(disseminated via email)*	Predetermined standard and plan *(disseminated via email)* Vertical communications *(via email)* Team meetings *(via teleconference)*	Predetermined standard and plan *(stored on online bulletin board)*	Predetermined standard and plan *(disseminated via email and stored on online bulletin board)* Vertical communications *(via email)*	Predetermined standard and plan *(disseminated via email and stored on online bulletin board)* Vertical and horizontal communications *(via email)*	Predetermined standard and plan *(disseminated via email and stored on online bulletin board)*	Vertical and horizontal communications *(via email)* Team meetings *(in the beginning, it was via ICQ, then it was via teleconference)*		Predetermined standard and plan *(stored on online bulletin board)* Vertical and horizontal communications *(via email)* Structured team meetings *(via teleconf. which was complemented with online bulletin board (in Task C-1, via videoconf.))*
Influential Factors in the Task Coord. Portfolio Design	Task dependence		• Task dependence, • Limited common time frame	Task dependence			• Task dependenc. • Perceived time constraints		Task depend -ence	• Task dependence, • Limited common time frame
Influential Factors in the IT Mediation	• Cognitive effort, • Ease of info storage + retrieval	Cognitive effort	• Cognitive effort, • Availability	Ease of info storage+ retrieval	• Cognitive effort, • Ease of info storage + retrieval		• Cognitive effort, • Ease of info storage + retrieval, • Communication ambiguity			• Cognitive effort, • Ease of info storage+retrieval, • Comm. Ambiguity, • Availability, • Physiological arousal
Task Coord. Effectiveness	Effective*	Ineffective: 1. Members in different locations interpreted the coordination information differently which led to redundant discussions 2. Some members accidentally deleted the email message which resulted in redundant work	Ineffective: Two members interviewed the same interviewee	Effective*			Ineffective: Two members were assigned to interview the same interviewees		Effective*	

* No unnecessary duplication of work by members or their leaving some parts of a task undone

Table VI. Summary of Findings

Task Dependence	Tasks	Members' Common Time Frame	Perceived Time Constraint	IT-Mediated Task Coordination Portfolio Used	Effective Coordination
Pooled	A-3	NA	L	RSP	Y[#]
	B-1	NA	L	SP	N
	B-2	L*	L	SP + VC + TM	N
	C-3	NA	L	RSP	Y[#]
Sequential	B-3	NA	L	RSP + VC	Y
Reciprocal	A-4	NA	L	RSP + VC + HC	Y
Team	A-1	H	L	RSP + VC + HC + TM	Y
	A-2	H	H	RSP + VC + HC + TM	N
	A-5	H	L	RSP + VC + HC + TM	Y
	C-1	L*	L	RSP + VC + HC + STM	Y
	C-2	L*	L	RSP + VC + HC + STM	Y
	C-4	L*	L	RSP + VC + HC + STM	Y
	C-5	L*	L	RSP + VC + HC + STM	Y

Note: SP = standard and plan; RSP = Repository-mediated standard and plan; VC = Communication technology-mediated vertical communication; HC = Communication technology-mediated horizontal communications; TM = Teleconference-mediated team meeting; STM = Teleconference complemented with repository-mediated structured team meeting; H = high; L = low; Y = yes; N = no

* Limited common time frame for team meeting; Not applicable (NA) when there is no team meeting
# The portfolio is effective if GVT has previously had effective team meeting coordination before its pooled task

Table VII. Optimal IT-Mediated Task Coordination Portfolios Based on Our Findings

Task Dependence	Members' Common Time Frame	Perceived Time Constraint	Optimal IT-Mediated GVT Task Coordination Portfolio Design
Pooled	NA	L	RSP[#]
Sequential	NA	L	RSP + VC
Reciprocal	NA	L	RSP + VC + HC
Team	H	L	RSP + VC + HC + TM
	L*	L	RSP + VC + HC + STM

Note: RSP = Repository-mediated standard and plan; VC = Communication technology-mediated vertical communication; HC = Communication technology-mediated horizontal communication; TM = Teleconference-mediated team meeting; STM = Teleconference complemented with repository-mediated structured team meeting; H = high; L = low

*Limited common time frame for team meeting; Not applicable (NA) when there is no team meeting
The portfolio is effective if GVT has previously had effective team meeting coordination before its pooled task or else may require VC as well