Vicious and Virtuous Cycles in Global Virtual Team Role Coordination

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Abstract

Role coordination is an important aspect of task performance in teams. This phenomenon has received little attention in global virtual teams (GVT) with their coordination hurdles. An exploratory study of two GVT was conducted to investigate role coordination. Our findings reveal that role ambiguity may lead to the emergence of individual roles in GVT contingent on task interdependency. In particular, high role ambiguity leads to the emergence of individual roles when GVT task interdependency is low but not so when it is high. These factors form a vicious cycle that hampers GVT role coordination. Another vicious cycle is formed when personal coordination mechanisms result in uneven distribution of information. Virtuous cycles are formed when group coordination mechanisms aid effective role coordination, preventing the emergence of individual roles and building shared team interaction mental models. In addition to vicious and virtuous cycles, we also identified technical roles as being salient in the GVT context.

Keywords
Global virtual team, role coordination, roles in team work, coordination modes.

1. Introduction

In today networked world, work has increasingly become designed for teams than for individuals and is more likely to cross boundaries than to be confined within particular organizations or functions [7]. Global virtual teams (GVT) represent one such work structure. GVT are groups of geographically and sometimes organizationally dispersed people who carry out interdependent tasks and communicate mainly through Information and Communication Technologies (ICT) [9, 24]. Fast response to customer needs, human resource flexibility, and knowledge workers with unique skills to complete challenging tasks are among the benefits promised by GVT [31]. However, they may be undermined if organizations fail to adequately address the challenges to the development of effective teamwork [10, 26].

Coordination is a fundamental activity to achieve effective teamwork [36]. Role coordination refers to managing the interdependent positions of actors engaged in concerted action [27]. It is mainly a task-oriented process aiming to manage group task roles, which refer to interdependent roles that help the group accomplish its goals [2]. While role coordination in traditional teams tends to be relatively less complex through reinforcing traditional hierarchies, GVT role coordination suffers from members being assembled on an as-needed basis [18]. With the lack of stable structure [36], the expectations of subtask allocation in GVT are often incomplete. This situation, known as role ambiguity, may produce stress for members. It may increase the likelihood of the presence of individual roles, such as blocker and aggressor, which are not beneficial for the team [3]. The presence of individual roles, in turn, indicates ineffective role coordination.

Since the structure of GVT seems to be the cause of the emergence of vicious individual roles, does this mean that GVT must unavoidably suffer from ineffective role coordination? In order to investigate the process of role coordination in GVT, we conducted an in-depth study of two GVT focusing particularly on the causes of the emergence of the individual roles as well as the coordination mechanisms that can prevent the emergence of these unfavorable roles. The study aims to offer suggestions on how effective GVT role coordination can be achieved.

2. Literature review

2.1. Task interdependency

GVT are formed to accomplish tasks that may vary in the amount of uncertainty which the team must deal with during task execution [13]. One source of uncertainty is task interdependency [8, 25]. Task interdependency can be classified in terms of its work flow into four types: pooled, sequential, reciprocal, or team interdependence [32]. These types are in increasing order of interdependency. In pooled interdependence, each member will complete their task independently and then aggregate it. In sequential

interdependence, tasks depend on completion of other tasks before beginning. While sequential interdependence tasks flow in one direction, reciprocal interdependence tasks flow in a "back and forth" manner. In team interdependence tasks, there is no measurable temporal lapse in the flow of the work between members. For such tasks, members will concurrently diagnose, problem-solve, and collaborate as a group to deal with the task. Task interdependency is likely to affect the way in which roles are taken up by GVT members.

2.2. Roles in team work

GVT are special type of teams which demonstrate task interdependence in a virtual environment. Among the unique characteristics of GVT members, being assembled on an as-needed basis [18] results in an evolving structure [36] where the expectations of who should do what subtasks are incomplete or insufficient. This is further complicated by the heavy reliance of GVT on ICT to coordinate their roles. For example, using e-mail for role coordination does not guarantee that all members receive the message and/or the intended meaning of the message is correctly interpreted. Role theory may throw light on how effective role coordination can be achieved in GVT.

Role is a dynamic set of recurring behaviors, both expected and enacted, within a particular group context [5]. Role theory presumes that individuals are members of social positions and hold expectations of their own behaviors and those of other persons [4]. Roles have been studied at many levels of analysis, including the group level. Benne and Sheats [2] observed interacting groups and developed a typology for group roles, which consists of group-task roles, maintenance roles, and individual roles. The classification was based on extensive observation of interacting groups and is consistent with previous group literature that recognizes the importance of both task-oriented and socio-emotional behaviors [15].

Group-task roles are roles that help a group develop and accomplish goals [2]. These are task-related roles, which consist of proceduralist (procedure person, moderator, agenda-keeper), recorder (record-keeper), evaluator (devil's advocate, critic), explainer (elaborator, coordinator, orienter, summarizer and amplifier), information/opinion seeker, and idea generator roles [37]. Maintenance roles or socio-emotional roles [37] are roles that do not directly address a task itself but help foster group unity, positive interpersonal relations, and development of the members' ability to work effectively together [2]. Examples of maintenance roles are motivator, gatekeeper (participation monitor), mediator (harmonizer, compromiser, conflict handler) and tension-releaser [5, 37]. Group task roles and maintenance roles are two important elements for effective groups [37]. Individual roles are roles that are related to the personal needs of group members and often negatively influence the effectiveness of a group [2]. Some typical individual roles include: aggressor, blocker, recognition seeker and dominator [5].

Previous literature suggests that evolving group-task roles (such as in GVT) can cause both manifest and latent disagreements among team members, leading to the emergence of individual roles, which in turn, often negatively influence team effectiveness [2]. Such role conflict (defined as the concurrent appearance of two or more incompatible expectations for the behavior of a person [37]) is one of the several structural conditions that are thought to cause problems in social systems. Other conditions are role ambiguity (in which expectations are incomplete or sufficient to complete the behavior), role malintegration (when roles do not fit well together), role discontinuity (when the person must perform a sequence of malintegrated roles) and role overload (when the person is faced with too many expectations) [3]. Each of these conditions may produce stress for members and increase the likelihood of the presence of individual roles which are not beneficial for the team.

The above findings suggest that GVT should attempt to prevent the occurrence of individual roles. A team member may assume different roles at different points of time. For example, he/she can be evaluator, gatekeeper and aggressor at different points of time. For team effectiveness, it is desirable for team members to exercise their group-task roles and maintenance roles more often than their individual roles. Effective role coordination is thus needed to coordinate the roles of team members engaged in concerted action such that group-task roles and maintenance roles are promoted; whereas individual roles are avoided.

2.3. Coordination mechanisms and shared mental models

Theory on task coordination mechanisms in traditional teams may provide a useful start to investigate such mechanisms in GVT role coordination. Previous studies have suggested a typology of three modes of coordination i.e., impersonal, personal, and group [33]. Impersonal coordination mode involves a codified blueprint of action which requires minimal verbal communication between task performers. Typical mechanisms for this mode are pre-established plans, schedules, formalized rules and procedures. Personal coordination mode involves dyadic communication between two members on a personal basis or communication that does not include all team members. Its coordination mechanisms are either vertical or horizontal channels of communication [32]. Group coordination mode exercises group communication. Mechanisms include team meetings that give members the opportunity to coordinate their group-task roles directly with one another [33].

Team cognition literature suggests that coordination mechanisms can aid coordination through developing shared mental models [12]. According to Stout et al. [30], under conditions in which communication is constrained by various limitations, e.g., in the case of GVT, teams are not always able to engage in necessary strategizing. In such cases, shared mental models may be crucial to team functioning. Among the various kinds of shared mental models [23], team interaction mental model is likely to be

directly related to role coordination. Team interaction mental model is an organized knowledge structure that allows members to describe their roles and responsibilities, interaction patterns, information flow, and role interdependencies [23]. Achieving shared team interaction mental model is the outcome of effective role coordination that can lead to better task performance.

3. Research methodology

Case study methodology is particularly appropriate for this study for two reasons. First, research and theory pertaining to GVT role coordination are at their early, formative stage. In such situations, where the efforts reveal sticky, practice-based problems and where the context of action is critical, case study research is considered appropriate [1]. Furthermore, since we aim to study contemporary phenomenon within its real-life context without controls over behavioral events to generate theories from practice, case study is the suitable approach [1, 11, 35].

3.1. Case background

The two GVT in this study, labeled as team A and B, were made up of Masters students from three universities (located in North America, Europe, and Asia) participating in a course on Global Project Coordination lasting 5 months. Each GVT was required to complete a global industry-sponsored project that was formulated, monitored and assessed by their respective organizational sponsor through a project manager. The teams closely approximated organizational GVT in terms of task and project realism. Team members were selected by matching their resume and skills profile to the project requirement, as is done in organizational GVT. At the end of the course, each GVT had to present their results before the organizational sponsors and faculty. The industry sponsor and faculty from three universities then awarded them a grade based on their work quality.

The GVT met face-to-face once at the beginning and twice towards the end of the project. They attended weekly video-conferencing lectures conducted by faculty members from the three universities. Throughout their projects, they communicated and collaborated using various ICT, such as videoconferencing, teleconferencing, e-mail, ICQ (an instant messaging tool), e-Circle (a private online community tool), and web discussion boards. Thus, the teams under study fulfilled the key characteristics of GVT (i.e., global dispersion and reliance on ICT). Table 1 shows the demographic characteristics of the two GVT.

Table 1. Characteristics of GVT

	Team Size	Gender	University composition
A	7	3 F, 4 M	4 North America, 3 Asia
B	11	4 F, 7 M	5 North America, 4 Europe, 2 Asia

Team A worked on a global project sponsored by a major international computer company. The objective was to re-engineer the financial analyst (FA) organization within the sponsor company to attain a more effective structure. To achieve this objective, members of Team A had to interview different ranks of executives within the company to elicit ideas on how to improve the FA structure. Almost all aspects of team A's task such as interview questionnaire creation, consolidation of interview results, identification of problem areas, and generating the recommendation proposal required input from and coordination between all team members (i.e., team interdependence task). Team B worked on a global project sponsored by a major international consulting company. The goal was to understand risk assessment procedures in businesses in a variety of industries. Members were required to collect information about risk measurement, risk monitoring, and risk management in global businesses through interviews with top executives. The sponsor company had given them a pre-designed risk assessment questionnaire for data collection. Since members of team B could carry out their work quite independently of each other except during the data consolidation phase, the team task was deemed to be comparatively low in its level of interdependency (i.e., pooled interdependence task).

3.2. Data collection

Data was collected from multiple sources (see Table 2). The two teams were asked to archive their e-mails and send the e-mail logs to the researchers. All web discussion board postings were saved. Snap shots of e-Circle pages were archived. Some teleconference and videoconference meetings were videotaped. For synchronous meetings that were not videotaped, team communication was inferred based on meeting minutes. Transcription was done for every synchronous meeting that was videotaped. All available project documentation was archived including participants' lesson-learned papers, which consisted of their experiences and insights gained while working in their respective GVT.

Table 2. Data sources

Observation
• Face to face meetings
Synchronous communication logs
• Teleconference transcriptions
• Videoconference transcriptions
• ICQ transcriptions
Asynchronous communication logs
• Emails with attachments
• Web discussion board postings
• Snap-shot of e-circle pages
Project documentation
• Project descriptions
• Personal information of team members

- Lessons learned papers on ICT in GVT by members
- Team grades and grading criteria
- Team project reports

3.3. Data analysis

To analyze the data, we conducted template coding [21] and causal loop diagram (CLD) mapping [29]. Template coding was used to generate categories to represent the concepts of interest while CLD mapping helped to interrelate the template codes causally.

Template coding helps researchers begin the analysis process with more structure using on an original template of a-priori categories and sub categories based on previous literature [21]. Our original template was generated by synthesizing the literature on task interdependency [32, 33], roles typology [2], coordination modes [33], and shared mental models [23]. Template analysis consisted of perusing the data and modifying the template accordingly till a stable template was obtained. The modification included adjustment, insertion, and deletion of categories and sub-categories in the template based on the data analysis to retain theoretical flexibility [21, 11]. An example of code adjustment was when the *personal coordination mode* was specified by its sub-categories of *use of horizontal and vertical communication channels*. An example of a code added is *duplicate work*. This code was inserted due to the observation that in team A, two members simultaneously started to formulate and disseminate the questionnaire required for their project. A code deleted was *impersonal coordination mode* because there were no instances of usage of this coordination mode for role coordination in both teams. More discussion about the findings will be presented in the subsequent sections. The final template based on the data analysis is presented in Table 3.

Table 3. Final template of our study

Categories	Definitions
GVT Structure	
Task interdependency	Extent to which members are dependent upon one another to perform their job. It includes pooled, sequential, reciprocal and team interdependence [33]
Assembled on an as-needed basis	Assembled for the duration of a task and dismantled afterwards [18]
Problems Caused by GVT Structure	
Role ambiguity	(see Section 2)
Duplicate work	Multiple team members working on identical tasks [34]
Role Coordination Mechanisms	
Use of vertical communication channels	(see Section 2)
Use of horizontal communication channels	(see Section 2)
Team meetings	(see Section 2)
Roles in Team Work	
Group-task roles	(see Section 2)
Maintenance roles	(see Section 2)
Technical roles	Roles that are responsible to assess the media options available and perform the necessary configurations to help in the use of media by other members
Individual roles	(see Section 2)
Outcomes of Role Coordination Mechanisms	
Shared team interaction mental model	(see Section 2)
Even distribution of information	Information is equally distributed among members [8]
Group cohesion	Degree of mutual cooperation, confidence, and trust that exists among group participants [6]

Subsequently, in an inductive effort, we used the mapping technique of CLD to interrelate the generated templates causally [29]. A CLD consists of variables connected by arrows denoting the causal influences among the variables. Each causal link is assigned a polarity, either positive or negative to indicate how the dependent variable changes when the independent variable changes. We first conducted analyses within each case separately to allow unique patterns of each case to emerge [11]. Once we had captured the relationships among categories within cases, we tried to generalize the patterns across cases. Then, we looked for larger role coordination patterns over time [11, 35].

4. Within case findings

4.1. Findings from team A

At the beginning of their collaboration, the team's unclear structure led to role ambiguity. Two members unknowing of each other started to develop the questionnaire for the FAs whom the team needed to interview and sent their work to the rest of the team through e-mail. Facing a threat to group cohesion, another member quickly assumed a harmonizer role (maintenance role) to prevent possible conflict. The harmonizer took the initiative to determine whose work the team should retain. The problem of duplicate work could have caused the emergence of individual roles e.g., the member whose work got abandoned could have taken up the role of blocker or aggressor, but the high level of task interdependency prevented this from happening. Thus, while the evolving structure of the GVT led to role ambiguity, no individual role was observed following the conflict of duplicate work.

For the next subtask i.e., the interview process, one member assumed a dominator role (individual role) since there was a lack of shared team interaction mental model. This is shown in the following e-mail log: *Due to time constraint, I have taken the liberty to assign the people who will interview the FAs and Business Area Managers for the 3 countries. I hope you guys do not mind. ... Here is the assignment ...*

Following this e-mail, some members showed their agreement with this arrangement. None of the members assumed individual roles, such as blocker. Realizing their high task interdependency, team members tried to avoid conflict caused by individual roles. In fact, a few hours after the above e-mail, the erstwhile dominator and another collocated member assumed tension releaser roles (maintenance role) in order to ensure group cohesion. In an email they suggested: *We felt that everyone is working on the tasks that have been identified with little coordination. We are afraid that some times a lot of duplication of effort is being spent on some tasks and at other times not enough efforts are allocated to other tasks. Therefore, we thought that we could increase our efficiency and effectiveness by identifying tasks that are critical for the successful completion of our project and assign one or two of us to be the 'driver' for those tasks. The 'driver' will be responsible for coordinating, monitoring, and controlling the team's effort on the assigned tasks. ... Please give us your input whether you agree or not and add any suggestions that you might have.*

Several members also tried to act as tension-releasers (maintenance role) by cracking jokes. These maintenance roles were also able to aid group cohesion. As continued role ambiguity could cause the emergence of unwanted individual roles, team A started to coordinate members' roles using team meetings as observed from the ICQ chat log below:

<X> What about the distribution of the tasks? Y, do you have a list of tasks which we can assign to different people?
<Y> Z and I were thinking, why doesn't everyone think about the list of things we need to do and then we assign tasks according to each person's interest. ...
<X> another thing, I suggest we choose a monitor for the meeting. He / she should make sure that all the points are discussed, and refocus the dialogue if we are going off track.

Through these meetings, group-task roles and technical roles were observed to emerge in team A. Group-task roles included the assignment of a 'driver' for each sub-task. The driver would ensure that sub-task deadlines were met. He/she would also be in charge of soliciting and merging ideas into the best solutions for his/her subtask. This created a clear demarcation of responsibilities and a greater focus on the task.

The emergence of technical roles from the use of team meetings was evident from the ICQ chat log below:

<V> I don't think it's a waste of time to find an efficient way to communicate. The Yahoo Club is also very useful. I have been told we can create our own room. I need to ask Alex about this.
<W> Yes, but maybe some tools use the network more efficiently than ICQ. Maybe I'm wrong because I don't know too much about the subject.
<V> Several groups use it. It's very efficient!

The first member in the chat log above assumed a technical role. He stressed the importance of choosing the right medium for the team communication needs and also volunteered to assess the potential media options.

To make sure that every member had the same set of information, the ICQ record was captured and distributed via e-mail for the benefit of those who suffered from unreliable ICQ connection and for those who could not attend the meeting. Thus, even distribution of information about each member's roles and responsibilities was achieved through these meetings.

The enactment of group-task roles and technical roles as well as the even distribution of information were observed to lead to the emergence of shared team interaction mental models in the team. We also observed that maintenance roles improved the stability of shared team interaction mental models through fostering group cohesion. A member noted: *Despite the widely diverse culture, there is a lot of cohesiveness, team spirit, and teamwork in the group. Regardless of members' working and communication styles, there is a tacit agreement to be receptive and accommodate to the work arrangements.*

Once shared team interaction mental models had developed in team A, leaders in different areas could be observed and members' roles became clear. Interrelationships between members in the team, such as those who needed to collaborate more closely with each other to accomplish their tasks, became apparent. These developments resulted in a comparatively low role ambiguity as compared with the relatively high role ambiguity in the beginning of the team collaboration.

4.2. Findings from team B

As in the case of team A, being assembled on an as-needed basis led to high role ambiguity in team B in the beginning of their collaboration. However, in contrast to team A, duplicate work was not observed in team B. Unlike team A whose task needed input from all members, team B's task could be done independently by each member. Members in team B could identify local company executives to interview without worrying that their remote teammates would have an overlapping list.

However, although team B's task had low interdependency, lack of information about remote members worried some members about the progress of their project. Collocated members used horizontal communication channels to coordinate their roles. Sometimes the project manager used vertical communication channels to direct collocated team members without informing the rest of the team. A member wrote in the lessons learned paper: *Information is hard to get to everybody. Having the (project manager) in another part of the world with some parts of our team can cause problems. All the written information reaches us on the other side of the ocean, but the oral discussions between the project manager and those teammates do not always reach the other team members and that is not desirable.*

Even when the project manager wanted to inform the whole team through e-mail, the emails were sometimes lost or overlooked. Consequently, information was unevenly distributed among the team. This in turn caused the emergence of individual roles, such as recognition

seeker and dominator. The recognition seeker role was observed in a member's lesson learned paper: *Later in the project when the team presented their intermediate work to the executives of the sponsor company, one of the members expressed unhappiness for not being selected to present her work to the executives. This resulted in negative feelings towards her among the other members*.

In addition to the above coordination mechanisms, the team occasionally made use of the team meeting mechanism to try to resolve their role ambiguity and ensure even distribution of information. However, the meetings ended up being mainly for reporting purposes rather than for coordination purposes. After several team meetings, technical roles emerged, but group-task roles did not. The emergence of technical roles was seen in a member's web discussion board posting: *M is the one who always takes care of the teleconferencing arrangements. N is the one who does all the technical stuff although in the beginning O was the one who took the initiative for this*.

The unclear group-task roles along with the emergence of individual roles (e.g., recognition seeker) led to a low level of group cohesion in team B. This is seen in one of the e-mail logs: *Lot of inter-personal conflict has arisen …What I have learned is to be more clear in setting expectations for both the work level and ability to work as a team*. As none of the members assumed maintenance roles to foster group cohesion, the project manager divided the team into two subgroups and asked them to compete

with each other. Furthermore, with unclear group-task roles, shared team interaction mental models did not develop in the team. A member noted: *The role coordination in this team is done voluntarily and not explicitly discussed within the group. I personally feel that there is no clear division of responsibility*. As the project progressed, the low level of group cohesion could further be seen in a member's lesson learned paper: *This caused bad feelings about one another within the group and led to conflicts at personal and professional levels*.

Without shared team interaction mental models, team B experienced relatively high role ambiguity from the beginning till the end of the project. One member noted: *Individuals thought that others were not doing anything when they had actually completed their own work and had done work for others*.

5. Cross case analysis and discussion

From the above within-case findings, we derive the cross-case summary shown in Table 4. Based on analytical generalization, we identified two vicious cycles which led to the emergence of individual roles in GVT and one cycle that prevented individual roles from emerging. The resultant model of GVT role coordination is shown in Figure 1.

Table 4. Cross case summary

|	Factors	Team A	Team B	Influenced by
Task interdependency	Task interdependency	Relatively high	Relatively low	N.A.
Problems caused by GVT members' structure	Role ambiguity	High (only in the beginning)	High	Assembled on as-needed basis and shared team interaction mental model
Problems caused by task interdependency and GVT members' structure	Duplicate work	High (only in the beginning)	N.A.	Task interdependency and role ambiguity
Role coordination mechanisms	Use of vertical communication channel	N. A.	High	Existence of role ambiguity
	Use of horizontal communication channel	N. A.	High	
	Team meetings	High	Low	
Roles in teamwork	Occurrence of group-task roles	High	Low	Team meetings
	Occurrence of technical roles	High	High	
	Occurrence of maintenance roles	High	Low	N.A.
	Occurrence of individual roles	Low	High	Task interdependency, role ambiguity, and even distribution of information
Outcomes of role coordination mechanisms	Shared team interaction mental model	High	Low	Occurrence of group-task roles and technical roles, even distribution of information, and group cohesion
	Even distribution of information	High	Low	Individual roles, use of vertical and horizontal communication channels, and team meetings
	Group cohesion	High	Low	Occurrence of individual roles and maintenance roles
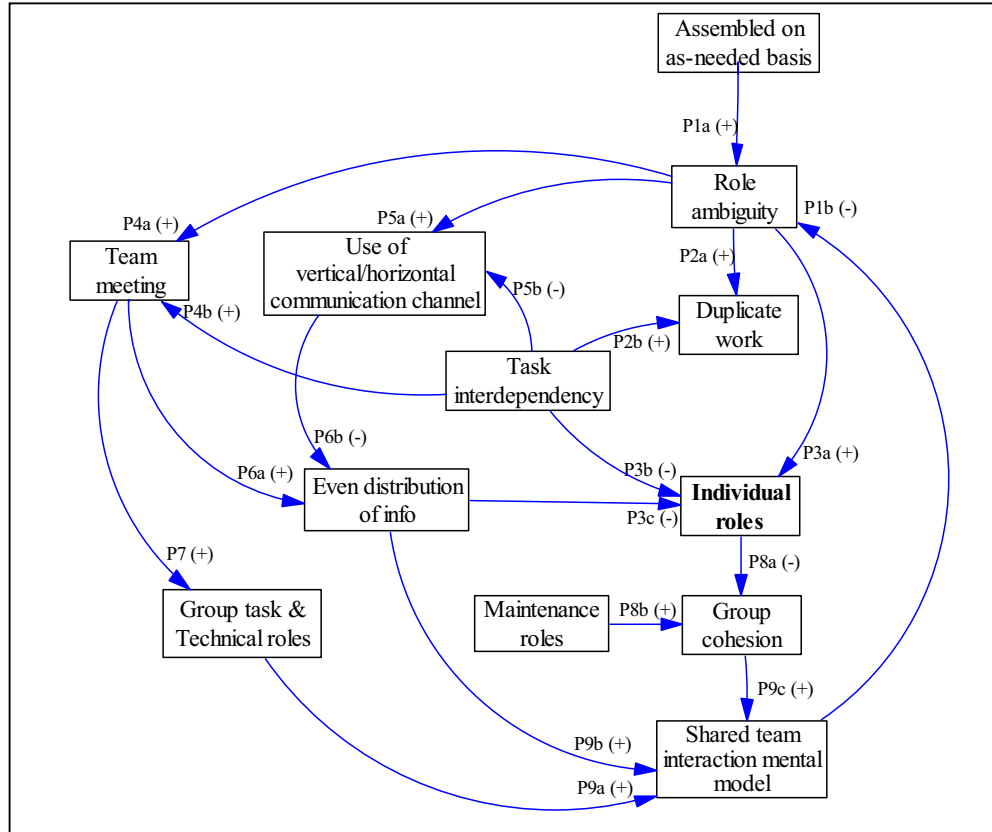
Figure 1. Proposed model of GVT role coordination

5.1. Vicious cycle 1: role ambiguity, task interdependency, and individual roles
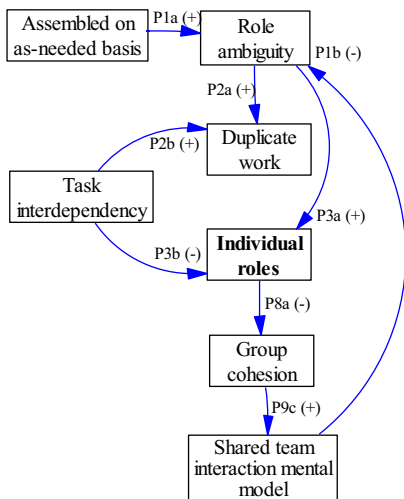
The first vicious cycle involves role ambiguity which leads to the emergence of individual roles when GVT task interdependency is low. The emergence of individual roles leads to reduced group cohesion and consequent lack of shared team interaction mental model which in turn

increases role ambiguity. This cycle is described below.

The finding that GVT have unstable and evolving structure in the beginning of their collaboration is in line with previous literature [36]. Both teams under study being assembled on as needed basis experienced role ambiguity i.e. ***Being assembled on as-needed basis, GVT have relatively high role ambiguity in the beginning of their collaboration (P1a)***.

Unlike team A whose task needed input from all members, team B's subtasks could be done independently by each member. Thus, duplicate work was observed in team A, but not in team B i.e. ***Role ambiguity is positively related to duplicate work in GVT with high task interdependency; but not so in GVT with low task interdependency (P2a, P2b)***.

The incidence of duplicate work did not lead to the emergence of individual roles in team A. The need to closely work together to complete the team's relatively high interdependency task suppressed the emergence of individual roles in team A. Although there was no duplicate work in team B, since all members have shared responsibility for the outcomes, team B members wanted to know what their remote partners were doing. Failure to have a complete and sufficient expectation of the roles and responsibility of each member led the emergence of individual roles in team B i.e. ***Task interdependency is negatively related to the emergence of individual roles (P3b); role ambiguity is positively related to the***

emergence of individual roles (P3a).

Subsequently, the existence of individual roles in team B was observed to destroy group cohesion which had a negative effect on the development of shared team interaction mental model i.e. ***Individual roles are negatively related to group cohesion (P8a); Group cohesion is positively related to shared team interaction mental model (P9c)***. Without shared team interaction mental model, role ambiguity in team B was observed to be relatively high from the beginning till the end of their team collaboration i.e. ***Shared team interaction mental model is negatively related to role ambiguity (P1b)***.

5.2. Vicious cycle 2: use of personal coordination mode and individual roles

The second vicious cycle involves role ambiguity leading to the use of personal coordination modes which causes uneven distribution of information and the consequent emergence of individual roles. The emergence of individual roles leads to reduced group cohesion and lack of shared team interaction mental model which in turn increases role ambiguity. This cycle is described below.

Role ambiguity led to use of group coordination mode in team A and personal coordination mode in team B i.e. ***Role ambiguity is positively related to the use of team meeting (group coordination mode), horizontal and vertical communication channels (personal coordination mode) (P4a, P5a)*** (see Figure 1). Further, we found that the frequency of using either group (in team A) or personal (in team B) coordination mode was determined by the team's task interdependency. In particular, ***Task interdependency is positively related to the use of group coordination mode (P4b) and negatively related to the use of personal coordination mode (P5b)*** (see Figure 1).
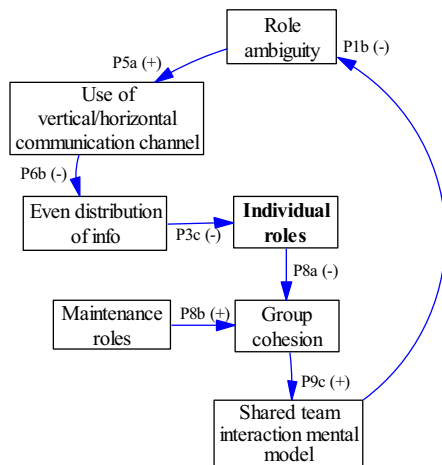

The high usage of personal coordination mode in team B resulted in uneven distribution of information i.e. ***Use of vertical/ horizontal communication channels is negatively related to the even distribution of information (P6b)***. This may be attributed to the fact that personal

coordination modes do not involve the whole team. The imbalanced involvement of members in the coordination process would cause the information flow to be restricted within a few members. Another related reason may lie in the ICT used to perform coordination. E-mail was the main ICT used to support personal coordination mode. Whereas some e-mail systems automatically informed senders that their message could not be delivered to a particular member, others did not have this capability. Consequently in the latter systems, senders did not know that their message didn't reach some remote members. Moreover, due to the large volume of e-mail exchange, some members overlooked certain messages. Due to the limited capacity of e-mail storage, these overlooked messages were sometimes deleted without being read. Thus, ICT may turn out to be the hindrance for even distribution of information.

In team B, members complained about the lack of knowledge about others' roles and responsibilities, which consequently caused some members to assume individual roles, such as blocker and aggressor. Conversely, ***Even distribution of information is negatively related to the emergence of individual roles (P3c)***. Without any members in team B assuming maintenance roles ***i.e. Maintenance roles are positively related to group cohesion (P8b)***, these individual roles could easily destroy group cohesion ***(P8a)***. Similar to the first vicious cycle, with low group cohesion, team B had difficulty in establishing shared team interaction mental model ***(P9c)***. As a result, team B had relatively high role ambiguity from the beginning till the end of their team collaboration ***(P1b)***.

5.3. Virtuous cycle: use of group coordination mode and shared team interaction mental model
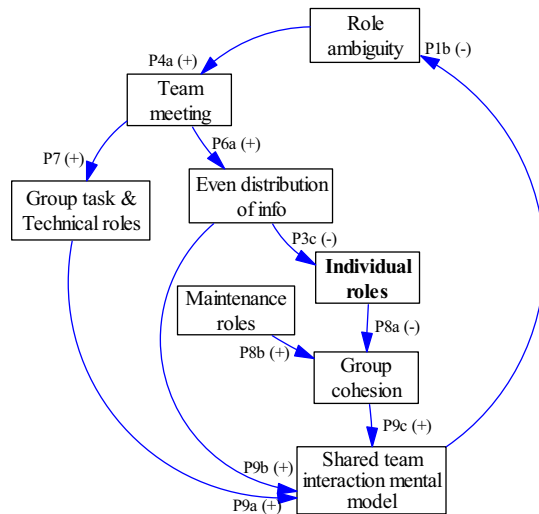
The virtuous cycle involves role ambiguity leading to the use of group coordination mechanisms which causes even distribution of information and the consequent prevention of individual roles. The lack of individual roles leads to increased group cohesion and greater shared team

interaction mental model which in turn reduces role ambiguity. This cycle is described below.

In contrast to team B, team A frequently used team meeting mechanism (group coordination mode) to coordinate their members' roles and responsibilities. This led to the emergence of group-task and technical roles in the team i.e. *Team meeting (group coordination mode) is positively related to the emergence of group-task roles and technical roles (P7)*. Technical roles are additional roles found in GVT, which may not be prevalent in traditional teams. The existence of these roles can be attributed to GVT's dependency on ICT to accomplish their tasks. Furthermore, we also found out that *Team meeting (group coordination mode) is positively related to the even distribution of information (P6a)*. In ICT-mediated team meetings, the synchronicity of ICT used facilitated the detection of disconnected members. For example, when some members were disconnected in the middle of the ICQ meeting, it was relatively easy for other members to detect these problems. Team A members would send the meeting minutes by e-mail to the whole team and/or post them on the web discussion board.

By maintaining even distribution of information, team A could prevent the emergence of individual roles *(P3c)* and establish shared team interaction mental model i.e. *Even distribution of information is positively related to shared team interaction mental model (P9b)*. As the team members enacted group task roles and technical roles, they were able to develop shared team interaction mental model i.e. *Group-task and technical roles are positively related to shared team interaction mental model (P9a)*. Maintenance roles also helped team A to sustain their shared team interaction mental models through maintaining group cohesion *(P8b, P9c)*. Having a shared team interaction mental model, role ambiguity in team A was relatively low from the middle till the end of their collaboration *(P1b)*.

6. Conclusion

As a contribution to GVT research, this study presents one of the initial efforts towards understanding GVT role coordination. A framework for GVT role coordination is proposed for further empirical validation based on in-depth analysis of two GVT. Our study reveals two vicious cycles and one virtuous cycle of GVT role coordination. The first vicious cycle suggests that the emergence of individual roles in GVT is not merely due to their role ambiguity as with traditional teams. Instead, it is an interaction between the role ambiguity and GVT task interdependency characteristics. In particular, high role ambiguity leads to the emergence of individual roles in GVT with low task interdependency; but not so in GVT with high task interdependency. The second vicious cycle unveils that use of personal coordination mode may result in uneven distribution of information, leading to the emergence of individual roles. Finally, the virtuous cycle indicates that use of group coordination mode may prevent the emergence of individual roles and build shared team interaction mental model. These findings suggest ways for

GVT to recognize the cycles they are in and attempt to foster virtuous cycles or break out of vicious cycles. This elaborates on previous research which suggests that GVT may have difficulty to optimally organize their workflow and manage internal processes [20] [28].

This study identifies an additional role, technical role, in the GVT context. This role is salient due to GVT's dependency on ICT to collaborate. Technical roles are responsible for assessing the media options available and performing the necessary configurations to help in the use of media by other members. Subsequent research on GVT role coordination may want to examine the implications of this role in greater depth.

As with other studies, this study suffers from several limitations. In particular, the study of two teams may decrease the external validity of the findings. Future work can be directed towards validating the framework on a larger sample of teams. Further, although the GVT in our study are far more realistic than typical student teams, the results need to be validated on organizational GVT. Nonetheless, our study provides inputs for future research on GVT role coordination and encourages GVT practitioners to pay careful attention to the vicious and virtuous cycles that occur in GVT role coordination.

7. References

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