Understanding the Functions of Teleconferences for Coordinating Global Software Development Projects

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Abstract

One of the dominant characteristics of contemporary software development is the global distribution of tasks, of developers, of information and of technologies. Undoubtedly, such distribution engenders new coordination challenges in the form of distance-related interdependencies. One of the predominant processes of addressing these challenges is electronic meetings (or teleconferences). However, the functions of these meetings for coordination purposes are not yet understood. The distinctive conventions of teleconferences and their causal relationships that lead to optimal coordination of global software development (GSD) projects are also not yet understood. In this paper, the functions of teleconferences held by globally distributed software developers to coordinate their work in the face of global distribution of resources, cross-site information interdependencies, and continuously changing software requirements are analysed. The analysis is based on a qualitative study of how a subunit of 13 software developers, distributed across three sites in the USA and one in Republic of Ireland, used teleconferences to address its coordination challenges. The paper proffers a teleconference approach to GSD coordination by arguing that the functions of teleconferences manifest in software developers' multitasking; their ready access to all their information as additional benefits; flexibility in their communicative behaviours; and a reduction in their structure overload. This approach draws attention to these manifestations as distinctive conventions of the de-structured meeting, which de-structuring is occasioned by organic information processing needs in teleconferencing. This approach also explains why the combination of global distribution and teleconferences is a strategic opportunity for information processing for software process coordination.

Keywords: coordination, interdependence, distance, teleconference, information processing, structuring, global software development

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One of the dominant characteristics of contemporary software development is the global distribution of tasks, of developers, of information and of technologies. Undoubtedly, such distribution engenders new coordination challenges in the form of distance-related interdependencies. One of the predominant processes of addressing these challenges is electronic meetings (or teleconferences). However, the functions of these meetings for coordination purposes are not yet understood. The distinctive conventions of teleconferences and their causal relationships that lead to optimal coordination of global software development (GSD) projects are also not yet understood. In this paper, the functions of teleconferences held by globally distributed software developers to coordinate their work in the face of global distribution of resources, cross-site information interdependencies, and continuously changing software requirements are analysed. The analysis is based on a qualitative study of how a subunit of 13 software developers, distributed across three sites in the USA and one in Republic of Ireland, used teleconferences to address its coordination challenges. The paper proffers a teleconference approach to GSD coordination by arguing that the functions of teleconferences manifest in software developers' multitasking; their ready access to all their information as additional benefits; flexibility in their communicative behaviours; and a reduction in their structure overload. This approach draws attention to these manifestations as distinctive conventions of the de-structured meeting, which de-structuring is occasioned by organic information processing needs in teleconferencing. This approach also explains why the combination of global distribution and teleconferences is a strategic opportunity for information processing for software process coordination.

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Introduction

One of the dominant characteristics of contemporary software development is the global distribution of tasks, of developers, of information and of technologies. Research on global software development (GSD) suggests that, in spite of the promises of modern and advanced information technologies, new organisational challenges are inevitable offshoots of such globalization (see, for example, 1999; Nicholson and Sahay, 2001; Espinosa and Carmel, 2003; Herbsleb and Mockus, 2003; Grinter et al., 1999; Wiredu, 2007; Oshri et al., 2008). In the face of global distribution of resources, however, managing the interdependencies and their related uncertainties between these resources to work is a most crucial organisational challenge of GSD. "Managing interdependencies between activities" defines coordination (Malone and Crowston, 1994, p.90); and a vital process for coordinating activities is meetings.

Software development is normally replete with meetings because they update developers mutually and constantly about task progress and challenges (Levesque et al., 2001). They are platforms where conflicts (and potential ones) are expected to be managed (Walz et al., 1993). Mutual awareness, collective decision-making and conflict resolution are all fundamental requirements for optimal coordination because a deficiency in any of them undermines the management of interdependencies. As GSD largely precludes face-to-face meetings, teleconferences which are enabled by electronic meeting systems (EMS) are employed as their surrogates. But in information systems development research, the functions of teleconferences in coordinating such projects are not yet understood.

Existing literature shows that one group of scholars has been researching the functionality of electronic meetings from perspectives apart from coordination, while the other has been researching coordination from perspectives apart from the functionality of electronic meetings (see summarized review in Table 1). As each group has not related its research to the other, the result is a gap of understanding concerning the functionality of electronic meetings for coordination. As more organisations are globalising their software development activities increasingly (see Carmel and Tjia, 2005; Sahay et al., 2003; Carmel, 1999), the trend has brought with it new characteristics that give new significance to teleconferences. A teleconference is a meeting, and a meeting is a genre of organisational communication characterised by its own structural, linguistic and substantive conventions (Yates and Orlikowski, 1992). These conventions differentiate it from other communication modes such as e-mails, one-to-one phone calls and instant messages. Therefore, to understand the

coordination functions of the teleconference, including its underlying technology, it has to be analysed separately and in sufficient detail. It is important not to lump the possible modes of communication together as though the relationship between the specific conventions of each genre on the one hand and the peculiar characteristics of GSD on the other is not critical to the understanding of its coordination function. This paper, therefore, seeks to fill this gap through explanations of the distinctive functions of teleconferences for management of interdependencies and their related uncertainties.

The research presented and analysed here addresses the question: How can the functions of teleconferences for coordinating GSD projects be understood? Through findings from an empirical study of teleconferencing in a subunit of a large multinational information technology organisation this question is addressed. The functions of teleconferences held by a team of 13 software engineers distributed into four sites (three in the USA and one in Ireland) is analysed in terms of managing cross-site interdependencies and their related uncertainties. This analysis reveals that the team's teleconferences facilitated each participant's ready access to all of his or her information and their multitasking. These manifestations are explained as flexibility in developers' communicative behaviours and reduction of their structure overload. They are conceptualised as distinctive conventions of the de-structured meeting, which de-structuring is occasioned by organic information processing needs in teleconferencing. Thus, the teleconference approach to coordination opens the black-box of electronic meeting processes by showing the interplay of their social, structural and technical elements. This approach also explains why the combination of global distribution and teleconferences is a strategic opportunity for information processing for software process coordination.

Table 1: Summarised review of the literature on electronic meetings and on global software coordination

	Parameter focused on	References	Shortcomings in terms of understanding the functions of teleconferences for coordinating GSD projects
Existing research interest in the functionality of teleconferences	Task complexity	Dennis and colleagues (2001); Zigurs and Buckland (1998)	They do not give specific attention to coordination, much more to the challenges induced by software complexity and global distribution of resources.
	Social action	Ngwenyama (1998)	
	Interdependence construction	Karsten (2003)	
	Strategic management	Tyran and colleagues (1992)	
	Conflict management	Poole and colleagues (1991); Sambamurthy and Poole (1992)	
	Group structure	McLeod and Liker (1992)	
Research interest in coordination of global software development	Obtaining the right balance between formal and informal communications	Grinter and colleagues (1999)	Do not implicate teleconferences directly
	Using software architectures, plans and informal ad hoc communications	Herbsleb and Grinter (1999)	
	Mechanisms and processes that can address distance-related delays in communications	Herbsleb and Mockus (2003)	Do not particularly address the potential role of teleconferences as coordination processes
	Knowledge-based perspective: facilitating knowledge flows, making knowledge explicit, amplifying knowledge, and building social capital	Kotlarsky and colleagues (2008)	
	Time/cost modelling of the effects of distance	Espinosa and Carmel (2003; 2007)	

Research Setting

In view of these intended contributions, a globally-distributed team or subunit of a multinational information technology organisation , called Bork, was studied from early May 2006 to late January 2007 as it upgraded a data mining application. The team (Team Gamma) developed an application, called Gamma, for remote data collection from its external customers' servers. Gamma would be part of a broader application called Supporter. Supporter was aimed at enhancing Bork's services to its customers who purchased and used their hardware (external customers). Several other subunits in Bork, called Release Partners (RPs), were involved in developing Supporter. Together, Gamma and its RPs constituted a bigger meta-unit called GammaServ. The RPs were, mainly, internal customers. These were

Bork engineers who used the Gamma application to connect remotely to external customers' servers for diagnosis and support. These internal customers comprised of three support groups or levels for addressing problems reported by the external customers.

Bork aimed to reduce the cost of warranty on its hardware products – "4% of 2005 revenue was put in the pot for warranty." It hoped to achieve this through remote connectivity and automated proactive data mining and diagnosing in external customers' servers. It also hoped to achieve cost reduction by relying on its expertise around the world and on various information technologies to develop its software.

Gamma was constituted by twelve engineers headed by a project manager (PM): three developers and one architect based in Killarney, Ireland; one support person and one developer based in Watertown, South Dakota (SD), USA; the Technical Lead (TL) and four developers in Bloomington, SD and one product release manager based in Los Angeles, California, USA. The software developers in all the sites communicated with each other, and this is represented by the bi-directional arrows in Figure 1. They all reported to the PM who was also based in Killarney in the same work area with the other four. The team was formed specifically to develop the Gamma application about April 2004; thus, during the period of the study, all its engineers had been working together since the team's inception. The SD developers were more experienced in developing remote connectivity applications and in agile development than the Killarney developers. The time difference between Killarney and South Dakota is 7 hours, signifying few overlapping hours of work between the two sites.

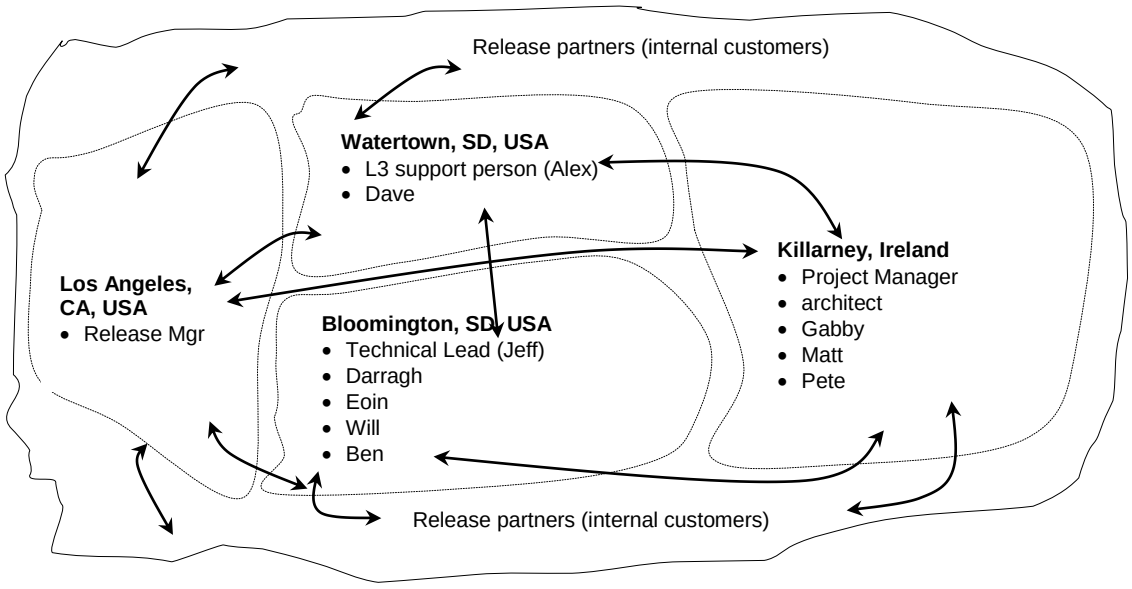

Figure 1: A sketch of the groups within Team Gamma and their locations

Note: Arrows signify communications; and all names are pseudonyms

Methodology

The epistemological foundation of this research is interpretivism (Walsham, 2006), while the ontological foundation is critical realism (Mingers, 2004, p.380). An interpretive epistemology was adopted because the software developers were crucial subjects of the empirical study. Human beings are social cultural beings with varying belief systems and interpretations. How they make sense of their social world could not be overlooked because the natural world cannot be equated with the social world (Schutz, 1954, p.267). The meanings they would give to their group dynamics, to their use of EMS and to their task were the sources of understanding. Alongside interpretivism, a critical realist ontology was adopted because the technology and the distributed structure of the software developers were objectively real albeit socially constructed (Searle, 1995). A case research strategy was also adopted because it is most suitable for exploring research problems in which unclear explanations exist between the phenomenon (the coordination functions of electronic meetings) and context (GSD) (Yin, 1984). Multiple data collection methods were combined to produce qualitative evidence, showing the richness of social reality in narratives and notes rather than in numbers. To ensure the credibility of this interpretive approach, multiple sources and methods were adopted to check their veracity and dependability.

Data sources and collection methods

My approach to data collection and analysis was exploratory, with the aim of understanding the coordination functions of teleconferences in globally distributed software development. Because the exploration was open to all possible areas of interdependencies in Gamma development, Diverse data collection methods were used. The data were collected through observations, document and e-mail analyses, short conversations, formal interviewing, and one long face-to-face meeting with the PM and two Killarney developers. These were done in 45 days out of the nine months.

The face-to-face meeting offered me the opportunity to seek their responses to how spatial and temporal distances between the sites affected interdependencies between them; to any communication challenges engendered by such interdependencies, and to how such challenges had been overcome. This 4-hour meeting proved invaluable because the superficial insights about these issues guided subsequent probing for more detailed insights about their resolution in the teleconferences that were observed.

Observing and listening to teleconferences represented the main communication mode in which all of the engineers in Gamma participated and contributed collectively. Through teleconferencing, mutual awareness among the team members was created regularly, the PM verified tasks statuses and assigned new ones, and participants engaged in collective discussions of pros and cons of new mini-proposals put forward by the PM to deal with changing requirements. There was at least one teleconference per week that involved all members of Gamma in mid-project (or normal) times; but as many as four per week could be held when releases were approaching (hectic times). Twenty of the teleconferences in which all members of Gamma participated over the period were listened to. The duration of teleconferences ranged from one to two-and-half hours. Static screen dumps were recorded, notes were taken and some remarks on the key issues of the study were transcribed verbatim.

Several informal conversations were held mainly with all the five Killarney developers. They were meant to fill the data gaps relating to just-completed teleconferences and document analysis.

Document analysis involved studies of the plans, programme defect reports, general reports, e-mail archives, schedules and presentations on Gamma throughout the period. These documents were many, and most of them could be accessed only from Bork's intranet. Thus, several days were spent poring over them at the Killarney worksite. The aim was to gain further understanding of the Gamma setting (structure, aims, functions, roles, responsibilities, etc), and to enhance continuous understanding of the key issues of the study.

The interviews with all five of the SD members were aimed at understanding their side of the story in terms of the data gaps and of the understanding of interdependencies and their management at Killarney. Because just a week was available to spend with them in both Bloomington and Watertown, it was prudent to use an interview guide with points like 'how distance between the sites affected interdependencies,' 'choice of communication modes to address task uncertainties and interdependencies,' and 'criticality of teleconferences.' These interviews were audio-recorded. The Bloomington members were interviewed individually to get personal perspectives from each of them. However, the two Watertown members were interviewed together to gain data based on a collective perspective through their corroborations, modifications or refutations of each other's responses. Apart from an interview with the SD Technical Lead which lasted about 70 minutes, each of the rest lasted about 45 minutes.

Data analysis

Data analysis began with inductive reasoning because it facilitates the formation of explanatory conceptions from evidence that is incoherent (Van de Ven, 2007, p.124). It was useful because the literature on EMS use in group work shows that work contexts are very diverse (see reviews by Morton et al., 2003; Pervan, 1998; Dennis et al., 1988). The unit of analysis was the management of interdependencies between the globally-distributed software development. The data were distilled to elicit the most essential roles played by the form, contents, and processes of teleconferences towards the management of interdependencies. these roles served as the primary themes, and were corresponded to three factors of interdependencies – the complexity of Gamma's software project, the experiential differences in the Team, and global distribution. Two or these roles were distinctive, and confirmed that the study context is practically different from those reported in the EMS literature.

These roles were abstracted into theoretical functions or secondary themes of GSD coordination. They were related to the objectified constructs which Dennis and colleagues' (1988) espouse in their research framework for the analysis of electronic meetings. This framework was useful for both comparison and abstraction because it incorporated the general constructs of the three factors of interdependencies had been discerned. However, it is limited in terms of its usefulness for analysing the form and substance of electronic meetings.

Yet it was important to analyze the form and substance of teleconferencing – which is a communication genre – relative to coordination in the abstraction. A genre is communication action characterised by similar form and substance and summoned in response to recurrent situations. The "observable physical and linguistic features of the communication" constitute the form, while "the social motives, themes, and topics being expressed in the communication" constitute the substance (Yates and Orlikowski, 1992; p.301).

Abstraction also made me apply information processing theory (e.g. Tushman and Nadler, 1978) to explain how teleconferences make distance a strategic opportunity for organic information processing in GSD coordination. The theory distinguishes between organic and mechanical processes. Organic processes refer to face-to-face, informal, spontaneous and verbal communications between people that create opportunities for feedback; and mechanical processes refer to communications that conform to formalized rules, pre-established plans, and standardized information technologies.

Results

The teleconference technology – called MeetRoom – connected all Team Gamma members through phone lines complemented by a virtual meeting room, remote desktop sharing and instant messaging software. Headsets-with-microphones were used in voice conversations instead of the normal phone handset. A developer joined a meeting by dialling a common number to an automated instructor which would instruct the dialler to enter a common conference code. This established a voice connection with all other conference participants. Then, using secure conference keys received from the conference presenter either beforehand or immediately after establishing voice connection, the developer executes the software that opens up the meeting room and avails instant messaging and remote desktop sharing to presenter and participants. At this point, a connection for voice, text and images exchange among participants is established, and the meeting would commence. The technology did not transmit video signals.

The interface of MeetRoom displayed textual representations of all people who were participating, and distinguished clearly between presenter(s) and participants. The interface showed all people online, it distinguished clearly between presenters and participants, and it identified clearly the person who was sharing a document. A being-shared document (and hence, desktop) would open in a new window; and the sharer would have the sole authority to modify any documents being shared. Modification of being-shared documents consisted of highlighting, deleting and inserting particular texts or images according to suggestions from participants. Switching of document sharing was agreed in verbal communication to the hearing of all attendees. There was no instance in the observations when the Whiteboard was used in a meeting.

The Technical Lead, who directed team affairs in terms of technical issues, designed task components in such a manner that the components were collocated at the three sites.

> "*One of the things I tried to do in terms of task interdependencies as Technical Lead is to minimize those interdependencies especially between Killarney and Bloomington and Watertown…I tried to design the tasks so that they are completely independent between the regions. I would not necessarily actually do that if it's between two engineers on the same site…."*

According to him, the tasks had to be independent "otherwise they would take very, very long times to finish." This collocation of task components led, at the same time, to cross-site information dependencies between the groups because they needed to be aware of and relate to the state of each component's development. Developers had to relate with their colleagues

in other sites by clarifying issues that would affect their own components. These were important because those components would be integrated during intermediate releases. The collocation of task components, therefore, resulted in uncertainties such as inadequate awareness and misunderstanding of issues. These uncertainties posed a threat to collective decision making because they would induce their teleconferences to be more devoted to resolving these cross-site uncertainties than to proactive endeavours such as coding and programme defect fixing.

Gamma development, on the one hand, was characterized by many variations and exceptional circumstances that are attributable to the iterative nature of their software development process. On the other hand, it was characterized by developers' need for more thinking time and dependence on the Bloomington developers who had greater experience in remote connectivity applications development. Team Gamma also collaborated collectively, in pairs, in threesomes, and so on, to be able to deal with the exceptional character of their task. They were usually uncertain about knowable outcomes of the non-routine development process. Will, a Bloomington-based developer, described their task as complex and explained it as follows:

> *"We have a series of what we call actions that our software can perform. And we have authorizations as to who can perform those actions. Right now we have a spreadsheet that says what all of our actions are and what do they do. But that's too complicated and we need to simplify that, and we've got multiple names for the same kind of actions. And it turns out that these two names are really meaning the same thing and we need to bring them together and so the complex problem is 'what do we want to call these and how do we want to coordinate our changes to our code in our database to resolve this issue?'*
>
> *This is going to require a collective phone meeting [teleconference]. Some of these problems you look at them and you might decide, I want to recommend a particular solution. And you come up with all the alternatives and you write it up and send it off in an email to the rest of the team or the team members who are interested in this particular area. And then they'll reply back with what they think, and you can narrow it down that way as well over email, but that usually takes longer. That takes days as opposed to an hour or so."*

Besides task complexity, the PM witnessed that their task environment was unstable. This, he explained, was due to the continuous changes in external customers' requirements. Such changes induced changes in business requirements of internal customers continuously,

and this affected Gamma because such requirements served as inputs for Gamma development.

"The relationship between Gamma and release partners [was] not that good; each partner [had] a different motive; commitment from them [was] not certain; engagement with them [was] continuous but the business requirements [could] be changed by a release partner arbitrarily; there [was] competition for shared resources by release partners; interdependencies [were] not smooth at all; business requirements baselines are changing continuously in Bork" (the PM)

These partners were operating from locations such as India, Brussells, other parts of USA apart from South Dakota, and Britain; and the spatial and temporal distances between them worsened the already erratic interdependencies. These erratic interdependencies constituted an instance of instability in the source of inputs for Gamma development because the developers' coding had to align with other RPs' coding to facilitate smooth integration of their efforts to make Supporter a success.

A more significant variation in Gamma's task environment was indicated by the highly critical nature of eleventh-hour changed requirements. In the early days of development, changing requirements were easier to deal with because there were enough time resources at developers' disposal. On the contrary, when the release was approaching, it was more difficult to deal with changing requirements because of the obvious time limitation. This means that the uncertainty engendered by the changing requirements for Gamma development was more critical when the release was approaching. The following excerpt, which exemplifies eleventh-hour requirements change, is a transcription of part of a teleconference that was held three days before the first intermediate release:

The release manager (RM) and the PM become concerned about James, who is responsible for Level 2 support, based in India and has just sent an email to the release manager with a set of new requirements concerning the impending release.

RM: I'm surprised he [James] doesn't understand what the scope is…. Certainly, we've got a lot of issues to be resolved and I don't know how we're going to resolve that.

PM: I think we're good to go.

RM: We need to take them one at a time and get back to them.

PM: It's the same every time. I'm frustrated. We don't know upfront what we need to do.

RM: Everything gets up to the last week.

PM: We have the support agreement and so why is all this…?

RM: It's gonna be an interesting one how we can answer these questions. I think we're almost guaranteed for rejection. We might get a conditional approval.

This instability in business requirements further engendered problems in Gamma's interdependent relations with its RPs. Thus, Gamma's inability to predict the changes in the state of business requirements was a typical instance of task-environmental uncertainty; and this translated into uncertainties in inter-unit interdependencies.

This is how Darragh explained the team's response to James' last-minute requirements:

"In that case, it was mostly emails. Jeff starts an outline. Ok, this is what we need to do, and here's what everybody's assigned to do, so go off and do it. And then we would send an update to the whole list; or you just reply-all and say ok I've got my part done and here it is. If we had a team meeting scheduled between [the time we learn about the changed requirement and release day], then we would discuss it in our team meeting [teleconference]. We usually didn't have a scheduled phone conference between the team, just the e-mail – broadcast email [using the team mailing list]."

Uncertainties from the task environment also required high agility from Gamma developers to deal with. The PM's witness corroborated the observation that developers' response was in drawing upon their agility to deal with these variations. This drawing was largely facilitated by the greater experience of the Bloomington developers in remote connectivity applications development, in general, and in agile development, in particular. Although Bork's regulations demanded Gamma's adoption of formal methods which entailed less operational costs, Gamma's challenges and its capacities for agile development within operational cost limits was crucial for dealing with task variations. The Team Philosophy, for example, read as:

"*fast, lightweight, nimble... Do the Right Thing ...at the expense of 'the process'*"

And the Engineering Methodology also read as:

"*Our engineering methodology is a combination of a larger, traditional phased approach for use in outward-facing communications, and an internal iterative "agile" methodology for use within the team.*

The larger methodology is required because we interface with many external organisations that impose this structure upon our team. However, within the team we use an iterative form of the 'agile' development methodology."

Apart from agility, the developers' continuous relationship building since the beginning of Gamma development had resulted in high mutual understanding which they exhibited to deal with eleventh-hour requirements. Only two developers had met the Kerry developers

face-to-face, so relationship building within technology-mediated communications was the foundation for developing this mutual understanding. For example, during the first meeting, the PM lamented about "guys making assumptions" in the early days of the project; and the two Kerry developers added that they had learned continuously about the preferences of Bloomington developers.

Managing Interdependencies with Teleconferences

Six main roles of Team Gamma's teleconferences for managing interdependencies are discernible from these results. Four of these six roles – mutual understanding, new assignments allocations, learning, and agility – have been discussed in the EMS literature, albeit in contexts different from GSD. However, they are important for identifying the categories of interdependencies that they help to manage. The other two – ready access to information and multitasking – are distinctive roles that will be the fulcrums around which further distinctive functions of teleconferences for coordinating GSD projects will be discussed.

Firstly, in view of the task complexity and its collaborative imperative, their teleconferences contributed significantly to the development of mutual understanding, and hence uncertainties reduction, across the sites. Through teleconferencing, scattered information was shared and understood as required for team cohesion and collective decision making. Verbal, textual and graphical pieces of information were shared by Gamma members, and these information representations corroborated each other to enhance Gamma members' mutual understanding.

Secondly, teleconferences served as platforms for new task allocations. The erratic interdependencies between Gamma and the Release Partners that often caused eleventh-hour changes in requirements were pretexts of uncertainties. The PM's verification of previously assigned tasks at the beginning of teleconferences and his allocation of new ones towards the end confirms this role.

Thirdly, learning was enhanced by the team's teleconferences. Although the Killarney developers reported that they sought expertise from the more experienced Bloomington developers through other communication media apart from teleconferencing, the Killarney developers also confessed their further learning from the Bloomington developers as the latter reported on their tasks to the PM in teleconferencing.

Fourthly, teleconferences served as important antecedents for agile development that was more necessary for dealing with eleventh-hour requirements. It was an important antecedent

because the meeting would pave the way for individual developers to work on the changes subsequently, work which largely required collaboration through emailing. Without the antecedent teleconference, the team would rely only on emailing for collaboration, and that would encumber their agility significantly because emailing is asynchronous.

Fifthly, teleconferencing contributed to their management of interdependencies through information sharing because the developers participated in these meetings from their own desks. From their desks, and hence from their computers, they had ready access to all information that needed to be shared even if such information was not predetermined to be shared at the beginning of or before the meeting. In collocated teleconferences, participants usually would have left their desks and come to the meeting room with only predetermined information to share. This means that, in case there is an emergent need to share non-predetermined information during the meeting, the participant would either postpone the sharing or have to excuse the others to fetch it from his or her desk. Teleconferencing, therefore, ensures every participant's *ready availability and access* to all of his or her information on his or her computer.

Sixthly, teleconferences allowed for *multitasking* by participants. The technology could show on a screen that a developer is participating, but he or she may be working normally and may not even be concentrating on what is being discussed in the meeting. The participant may be wearing his or her headphones with the sound coming into his or her ears, but may not be listening or may be listening only partially. Apart from the fact that this scenario is obvious, two of the Killarney developers confirmed that they sometimes multitasked during teleconferences and would only switch back on when they were specifically called upon to explain something by the PM or another developer. They explained that multitasking or less concentration on the meeting allowed them to continue their work in meetings where their participation and contributions were very marginal. Both of participation-at-the-desk and multitasking can explain how, through teleconferencing, Gamma's Release Manager became aware of James' queries, discussed the queries with the participants, composed a reply to James, and received a reply from him to further discuss with participants in the course of one meeting. Note that multitasking during teleconferences can, at the same time, undermine information interdependencies because the attendee's less concentration or partial listening to the discussions can cause him or her to miss vital information from the exchanges.

Each of the six roles addresses one of three factors of interdependencies that are also discernible from the results: those related to task characteristics, those engendered by group characteristics, and those related to global-distribution of resources. The function as a

platform for mutual understanding and new task allocations helps in managing interdependencies related to the complexity of software development. The function as a platform for learning and a precursor for agile development helps in managing interdependencies engendered by experiential differences in Team Gamma. The function as a resource for ready access to information and for multitasking helps in managing interdependencies related to global distribution of resources (see Table 2).

Table 2: Relationships between the Roles of Teleconferences and Interdependencies Management

Roles of Teleconferences	Factors of interdependencies they manage	Dennis and Colleagues' (1988) Constructs
Platform for mutual understanding	Those related to the complexity of *software development*	Task
Platform for new task allocations		
Platform for learning	Those engendered by *experiential differences* in Team Gamma	Group
Precursor for agile development		
Resource for ready availability and access to information	Those related to *global distribution* of resources	Context
Resource for multitasking		

These three factors of interdependencies combined with the teleconference technology are interesting because they constitute instances of the broad constructs that Dennis and colleagues (1988) espouse for the analysis of electronic meetings – task, group, context, and technology. However, these factors are peculiar to GSD; they are not directly reflected in the constructs of the research model of Dennis and colleagues; and they represent a different context altogether. For example, global distribution of resources and the MeetRoom technology, in particular, are instances that are very foreign to the model. In spite of these contrasts between these and the model's instances, the broad constructs are applicable to both sets of instances. Therefore, the model serves as a useful framework for theorizing the coordination functions of teleconferences in GSD, as it helps in explaining the relationship between the distinctive functions and GSD coordination.

Coordination Functions of Teleconferences in GSD Projects

The two distinctive roles of teleconferences which the empirical study brings to the fore are *availing ready access to all the participant's information* and *enabling multitasking*. Ihe bases of these roles, their resultants, and how they contribute towards the teleconference approach to coordination will be discussed (see Figure 2).

Both roles result from the inseparable combination of teleconferencing and global distribution or distance. Without any one of these bases, these roles would not manifest, and other roles such as mutual awareness and timely information sharing would be limited. Thus, it is interesting to note how teleconferences, which represented one way of addressing coordination challenges brought by distance, relate with the selfsame distance to address those challenges. To wit, the selfsame global distribution can engender coordination challenges and opportunities, and it is through the understanding of the functions of teleconferences that one can make a distinction between the challenges and opportunities. Thus, teleconferencing is not to be deemed as a mere reactive measure to address coordination challenges; but, rather, a proactive measure to actually enhance coordination by facilitating information generation, processing and sharing.

The opportunistic capacity of global distribution and teleconferences is proven further from the idea that they induce developers' flexibility-in-participation or flexibility in their communicative behaviours. The manifestation of this flexibility indicates that an environment of reduced structure overload is prevailing or will prevail. Structure overload is a situation where the process of information generation and processing is constrained by the imposition of structural and processual rules and regulations (Sørensen and Kakihara, 2002). These constraints are normally experienced by organisational units attempting to adapt to environmental demands for flexibility yet frustrated by rigid organisational structures. Thus, the imperative for face-to-face meetings to be held in special meeting rooms subsumes structure overload because it constrains participants' full access to their computers for information generation, processing and sharing. But the Gamma case indicates that their teleconferences permitted participants' full access to their information, especially for addressing both intra- and inter-unit interdependencies (see Figure 2). These were instances or manifestations of fewer constraints, more flexibility-in-participation, and reduced structure overload in their electronic meetings.

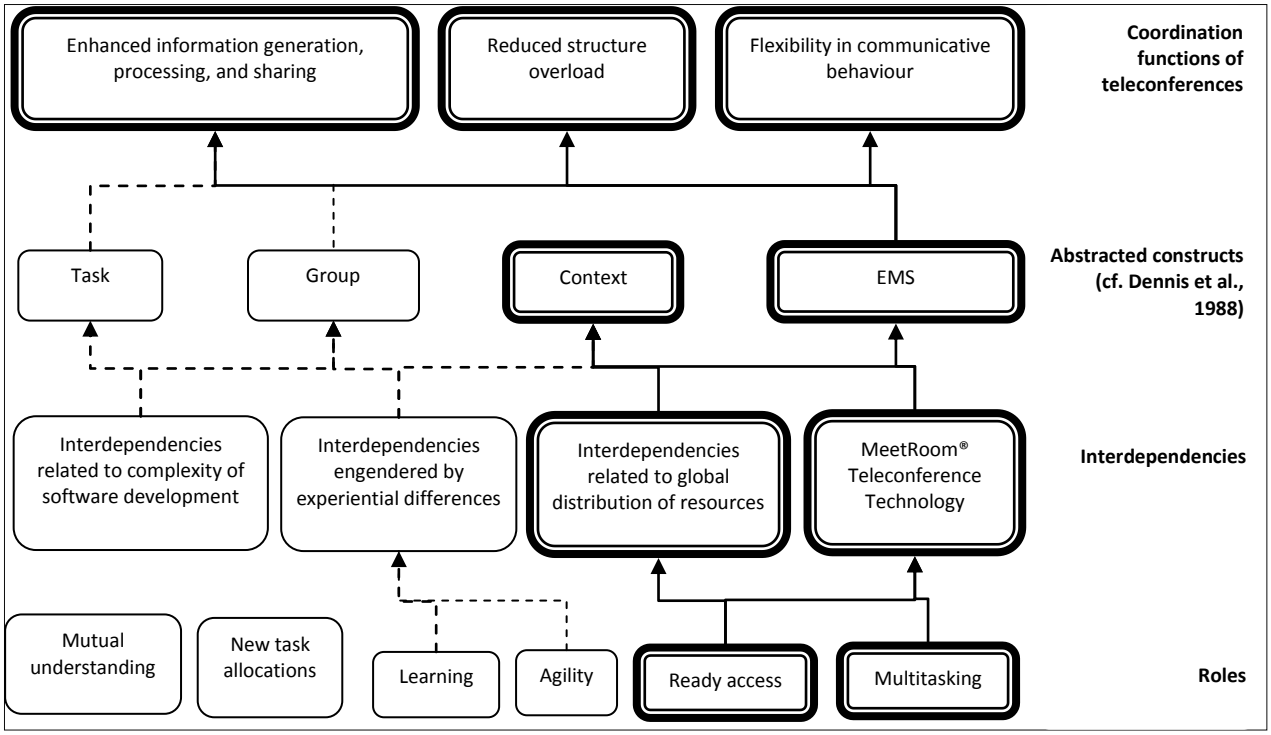

Figure 2: Analysis of the coordination functions of teleconferences (distinctive functions are emphasised)

When teleconferences function to draw positive benefits from distance, they are understood as means of exploiting physical or geographical structures. This idea is a challenge to previous perceptions of the globally-distributed structure of GSD. In previous research, this structure is usually deemed as a somewhat negative attribute, and rightly so when it connects with problems of culture (e.g. Nicholson and Sahay, 2001), of excessive communication delays (e.g. Herbsleb and Mockus, 2003), and of mutual knowledge sharing (Kotlarsky and Oshri, 2005). Even when it is perceived as positive, it is a result of benefits such as closer-to-market development and associated reduced cost (e.g. Casey and Richardson, 2004); access to a global pool of technical and experienced developers for innovation (e.g. Ebert and De Neve, 2001); and continuous, 24-hour or follow-the-sun development (e.g. Grinter et al., 1999; Trienen and Miller-Frost, 2006). Moreover, existing research views electronic meetings only in terms of their reactive capacities to address distance-related coordination challenges. The coordination approach to teleconferences suggests, however, that such global distribution is indeed a coordination opportunity. It does so by explicating functions of electronic meetings which enhance coordination mainly because of global distribution. The bases and resultants of the distinctive roles bring home the idea that teleconferences do not

only function to draw positive benefits from distance but also to induce flexible communicative behaviours in meeting participants.

When teleconferences function to induce flexible communicative behaviours, they are understood as weakening meeting structures. These understandings suggest that teleconferences are occasions for weakening meeting structures – that is, occasions for de-structuring. This resonates with Barley's (1986) idea that technology is an occasion for structuring the social and institutional orders of organisations. But the coordination approach to teleconferences points to the need to observe more closely the object and influence of the structuring occasioned by teleconferences. The object is the structure of the meeting genre which has its own substantive conventions (Yates and Orlikowski, 1992). This object was negatively influenced by the very teleconferences to result in organic information processing. A positive influence would render the genre more structured, would induce more rigidity in participants' communicative behaviours, and would not reflect organic information processing.

In the software development and research and development (R&D) literature, there is talk about the necessity of organic information processing in the form of face-to-face, informal, and spontaneous communications to coordinate work (see, for example, Van de Ven et al., 1976; Allen and Cohen, 1969; Tushman and Nadler, 1978). But through global distribution, such forms of organic information processing are surrogated with mechanical information processing in the form of technology-mediated communications. By inference, information processing would be debilitated because more organic information processing is desired for coordinating GSD than less (see, for example, Herbsleb and Grinter, 1999; Herbsleb et al., 2001). However, this paper suggests that organic information processing may not be debilitated if the use of the teleconference technology occasions a de-structuring of the structure of the conventional meeting genre to manifest in multitasking and ready availability of information. From the perspective of their forms, teleconferences are significantly different from face-to-face, informal and spontaneous communications. But from the perspective of their functions, they facilitate human's desire for flexibility in communicative behaviour and manifest reduced structure overload.

Therefore, information processing (mechanic or organic) in teleconferences is not to be understood just in terms of technology characteristics. Rather, organic or mechanic information processing is to be understood as a function of the structuring influence of teleconferences. The de-structuring of the structure of the meeting genre points to the idea that information processing is a more elastic concept involving technology, structure and task

considerations. The degree of de-structuring will determine the degree of organic information processing, and vice versa.

By this reasoning, multitasking, ready access to all information, flexibility in communicative behaviour, and reduced structure overload can be understood as unique substantive conventions of the de-structured meeting genre (Yates and Orlikowski, 1992). A unique substantive convention of a genre refers to its substance or function or service for a particular purpose as opposed to its mere structure. These substantive conventions of the de-structured meeting for organic information processing are unique because no other communication technology engenders such processes. Even a videoconference, the nearest example of electronic meetings to a teleconference, would not engender such processes because it either demands the attention or shows the actions of a participant.

Implications

The de-structuring influence of teleconferences implies that they can be deemed as facilitators of organic information processing, functionally speaking. But this functionality should be understood in the context of the software development task because the nature of the task demands organic information processing. Without this demand, as in the nature of other non-R&D tasks, this functionality will neither be desired nor be manifested. This implies further that the coordination functions of teleconferences should be understood in terms of the inseparable combination of the technology, the software development task and global distribution; and confirms the elasticity of the information processing concept. It is only by this combination that teleconferences as occasions for de-structuring can be seen as a sensible process.

Practically, project managers can learn from these explanations that reduced structure overload and flexibility in communicative behaviour are essential and strategic rather than normal conventions. Having proven to be distinctive and substantive to the de-structured meeting genre and for organic information processing therein, these conventions can be drawn upon by managers to improve upon processes of globally-distributed software projects. They can also serve as a backdrop against which requirements of EMS design for GSD coordination can be judged. In this judgement, electronic meeting technology facilities that will occasion de-structuring influences should be considered as crucial requirements for organic information processing.

Limitations of teleconferences

Teleconferencing facilitates synchronous and collective communications in a timely fashion, and its exchanged information is ephemeral. However, there are several coordination challenges that require asynchronous and one-to-one or one-to-many communications. There are also coordination challenges that require communication technologies such as e-mail which must leave persistent information. Thus, Gamma also deployed emailing, programme defect management, instant messaging and telephone technologies to help in managing cross-site information interdependencies. This is in spite of the fact that none of these complementary technologies made possible the developers' spontaneous, collective, informal and synchronous interactions at the same time, save the EMS.

Besides, the large time difference between sites that manifested in teleconferencing as the Bloomington developers' first duties of their day and most of the Killarney developers' last duties of their day could be problematic. Although the accounts of the Gamma developers did not point to the time difference as a problem, it could be so in other global software contexts. Developers in one site may be very tired while those in another may be very fresh during a teleconference. This means that if this persists over a long time, then timely information sharing and collective decision making will be affected significantly. This can be compounded by an even bigger time difference between developers teleconferencing, for example, from India and USA. The time difference, therefore, is a potential limitation of the coordination functionality of teleconferences.

Conclusion

This paper proffers a teleconference approach to GSD coordination by showing how the causal relationships between distinctive functions of electronic meetings can enhance software process coordination. It has shown that interactions in teleconferences are crucial for coordinating global software development: for managing interdependencies related to task characteristics, to group characteristics, and to global distribution. The paper reveals developers' multitasking and their ready access to all their information as distinctive functions whose effects are conceptualised as flexibility in developers' communicative behaviours and a reduction in their structure overload.

Through these conceptualisations the paper explains why the combination of global distribution and teleconferences is a strategic opportunity for the information processing facet of software process coordination. It draws attention to them as distinctive conventions of the

de-structured meeting genre. Therefore, it has underscored the teleconference approach as a way of inducing organic information processes for optimal coordination of global software development projects.

Previous attempts at addressing the GSD coordination challenge have approached the issue from perspectives other than electronic meetings. This is in spite of the fact that global software processes are replete with such meetings and constitute a predominant facet of project managers' coordination efforts and for developers' information processing. The oversight of the teleconference approach has also left unexplained the distinctive conventions of the de-structured meeting genre that is suitable for organic information processing. But this approach has allowed us to trace the teleconference process from its bases (global distribution and technology) through its manifest components and their interrelations (for information processing), to its end (GSD coordination). It has, therefore, unravelled the black-box of electronic meeting processes by showing the interplay of their social, structural and technical elements that enhance their functionality for coordination.

Acknowledgements

This research was conducted in the Social, Organizational and Cultural aspects of Global Software Development (socGSD) project at the University of Limerick, Republic of Ireland. socGSD was one of the LERO (the Irish Software Engineering Research Institute) cluster projects funded under PI grant 03/IN3/1408C by Science Foundation of Ireland (SFI). I am grateful my socGSD colleagues, Gabriela Avram, Daniel Sullivan, Michael Hales, Anne Sheehan, Anders Sigfridsson, and our leader, Liam Bannon, for their help in developing the seminal ideas of this paper during the 2 years I spent with them. I am also grateful to the informants in the studied organization who allowed access to them throughout the study period.

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