

Knowledge transfer in globally distributed teams: the role of transactive memory

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Abstract. *This paper explores the role of transactive memory in enabling knowledge transfer between globally distributed teams. While the information systems literature has recently acknowledged the role transactive memory plays in improving knowledge processes and performance in colocated teams, little is known about its contribution to distributed teams. To contribute to filling this gap, knowledge-transfer challenges and processes between onsite and offshore teams were studied at TATA Consultancy Services. In particular, the paper describes the transfer of knowledge between onsite and offshore teams through encoding, storing and retrieving processes. An in-depth case study of globally distributed software development projects was carried out, and a qualitative, interpretive approach was adopted. The analysis of the case suggests that in order to overcome differences derived from the local contexts of the onsite and offshore teams (e.g. different work routines, methodologies and skills), some specific mechanisms supporting the development of codified and personalized 'directories' were introduced. These include the standardization of templates and methodologies across the remote sites as well as frequent teleconferencing sessions and occasional short visits. These mechanisms contributed to the development of the notion of 'who knows what' across onsite and offshore teams despite the challenges associated with globally distributed teams, and supported the transfer of knowledge between onsite and offshore teams. The paper concludes by offering theoretical and practical implications.*

Key words: knowledge transfer, transactive memory, globally distributed teams, expertise

INTRODUCTION

Knowledge transfer has become a key issue for globally distributed work, such as global software development projects (e.g. Kotlarsky & Oshri, 2005), global business process outsourcing

(e.g. Feeny *et al.*, 2005) and infrastructure management (e.g. Beulen *et al.*, 2005). In these novel organizational forms, success depends on the rapid transfer of business and technological knowledge from and to offshore facilities. This transfer of knowledge may improve knowledge integration across various sites and products, and may contribute to successfully coordinating complex projects (Grant, 1996).

Globally distributed projects, consisting of two or more teams working together from different geographical locations to accomplish project goals, face major challenges in transferring knowledge across remote sites. For example, these teams confront cultural differences that may include, but are not limited to, different languages, national traditions, values and norms of behaviour (Carmel, 1999; Carmel & Agarwal, 2002). To overcome geographical distances and time-zone differences such teams mainly collaborate through information and communication technologies (ICTs), and occasionally meet face to face to discuss project matters.

Nonetheless, over the past decade, studies have demonstrated repeatedly that, despite advances in technologies, ICTs do not prevent breakdowns in the transfer of knowledge across distributed sites (e.g. Cramton, 2001). While ICTs are critical for knowledge-transfer processes in distributed teams, a neighbouring stream of studies within the information system (IS) field has considered human-related factors, such as trust (Jarvenpaa & Leidner, 1999; Ridings *et al.*, 2002) and interpersonal ties (Kanawattanachai & Yoo, 2002; Ahuja & Galvin, 2003), which may act as facilitators for knowledge transfer between remote counterparts.

In line with such advances in the IS field, scholars have increasingly considered the concept of the transactive memory as an enhancer of knowledge transfer (Nevo & Wand, 2005). The encoding, storing and retrieving processes involved in a transactive memory system (TMS) (Wegner *et al.*, 1985) could support the transfer of knowledge between individuals (Nevo & Wand, 2005). While the concept of transactive memory has been studied in the context of traditional organizational forms and colocated teams, little is known about the process through which a TMS in globally distributed teams could be created and could support knowledge transfer between remote sites. The few studies that have indeed explored the concept of transactive memory in virtual teams have highlighted the importance of it for team performance (e.g. Yoo & Kanawattanachai, 2001) without addressing the broader challenge of knowledge transfer.

To contribute to filling this gap, this paper explores how remote counterparts encode, store and retrieve information about the location of knowledge to support knowledge transfer between dispersed sites. In particular, this paper will address the following questions: *how does transactive memory enable knowledge transfer in globally distributed teams?* and *through what mechanisms can a TMS be created and maintained?* In order to understand knowledge transfer in globally distributed teams from a transactive memory perspective, this paper first explores knowledge-transfer challenges, and the development and use of a TMS in dispersed teams. This conceptual contribution is followed by an in-depth case study of global software development projects. The paper concludes by providing theoretical and practical implications and suggestions for future research.

THE CHALLENGES OF KNOWLEDGE TRANSFER IN GLOBALLY DISTRIBUTED TEAMS

Globally distributed teams – both within and between organizational boundaries – represent a new organizational form that has emerged in conjunction with the globalization of socioeconomic processes. Such teams have replaced the traditional single-site hierarchy and the functional department structure for various reasons. For one, companies in developed nations have outsourced parts of their information technology (IT) services and business processes to developing nations (Currie & Willcocks, 1998; Carmel & Agarwal, 2002). Short-cycle development and the launch of new products and software for global markets has required expertise from a range of geographical areas (Desouza & Evaristo, 2004). Following this trend, the transfer of knowledge has become a key challenge for global teams attempting to deliver products and services adjusted to local markets and yet aiming to standardize expertise and business and technological operations on an international scale (Sole & Edmondson, 2002). Indeed, this growing trend of outsourcing has increased the exchange of information and knowledge between knowledge workers located at offshore and onsite during different stages of product and service life cycles.

Knowledge transfer is a process through which one organization (or unit) identifies and learns specific knowledge that resides in another organization (or unit), and reapplies this knowledge in other contexts (Hansen *et al.*, 1999). On the individual level, Cutler (1989) has previously observed that knowledge transfer is indeed a process by which the knowledge of one actor is acquired and is reapplied by another. While the literature has so far provided various explanations as to how knowledge is transferred between individuals, e.g. through knowledge codification and socialization processes (Nonaka, 1994), several studies have expressed concern with regard to the transferability of knowledge between remote counterparts and dispersed teams, prompted by a number of factors.

First, the diversity of local contexts may exacerbate the stickiness of information (von Hippel, 1994), hampering the transfer of contextual knowledge between remote sites (Cramton, 2001). Second, remote counterparts often adopt unique local routines for working, training and learning (Desouza & Evaristo, 2004). These unique routines may obstruct the development of shared understanding of practices and knowledge across remote sites. Third, differences in skills, expertise, technical infrastructure and development tools and methodologies further raise the barriers for knowledge transfer between remote sites. And finally, time-zone differences reduce the window for real-time interactions (Boland & Citurs, 2001), thus limiting opportunities for remote team members to discuss, debate and explain diverse opinions and perspectives.

Indeed, while colocated teams may develop various memory systems that support knowledge transfer, globally distributed teams often face challenges in developing such memory systems that may provide support for the transfer of contextual and embedded knowledge. The following section discusses the concept of transactive memory and aspects relating to how such a memory system may act as an enabler of knowledge transfer in globally distributed teams.

TRANSACTIONAL MEMORY: THE CONCEPT

A TMS has been defined as the combination of individual memory systems and communications (also referred to as ‘transactions’) between individuals. The group-level TMS is constituted by individuals using each other as a memory source. Transactions between individuals link their memory systems; through a series of processes (i.e. encoding, storing and retrieving) knowledge is exchanged. Individuals encode information for storing and retrieval, similar to a librarian entering details of a new book in the particular library system before putting it on the shelves. Through encoding, knowledge is categorized (i.e. assigned labels that reflect the subjects of the knowledge) for systematically storing the location of the knowledge, but not the knowledge itself. Then, individuals store this information internally (building their own memory), or externally (storing it in artefacts or indirectly in other people’s memories). And lastly, information about the location of the knowledge or expertise is retrieved when someone else asks for it (Nevo & Wand, 2005). Retrieval thus consists of two interconnected subprocesses: person A asks person B for information; person B retrieves the information. As Nevo & Wand (2005, p. 551) simply put it, ‘knowledge is encoded, stored and retrieved through various transactions between individuals’ (see Figure 1). Wegner (1995) explains that for a TMS to work, three corresponding aspects to encoding, storing and retrieving should be considered. These aspects, which accommodate interactions between multiple actors, are:

- 1 directory updating: where actors keep information about ‘who knows what’ up to date;
- 2 information allocation: where actors decide in whose memory to store new information that arrives in the TMS, and;

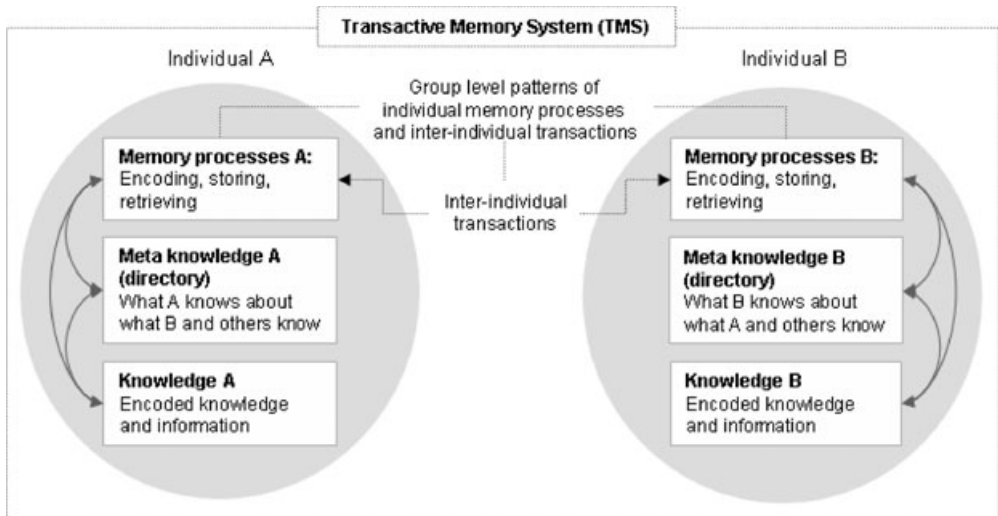


Figure 1. The concept of a transactive memory system (after Wegner, 1987).

3 retrieval coordination: where actors use a set of guidelines to determine in which order other actors should be consulted for the missing information.

In fact, a common assumption in the knowledge management literature is that the type of knowledge involved in a transaction (i.e. explicit or tacit) matches the type of knowledge management approach to capturing, storing and reapplying it (i.e. codified or personalized). Correspondingly, the literature distinguishes between codified (e.g. Hansen *et al.*, 1999) and personalized memory systems (e.g. Blackler, 1995). Similarly, based on Hansen *et al.*'s (1999) work, Desouza & Evaristo (2004, p. 87) discuss the differences between the codification-based and personalization-based knowledge approaches. With the codification approach, individual knowledge is 'made centrally available to members of the organization via databases and data warehouses.' The personalization knowledge approach, on the other hand, 'recognizes the tacit dimension of knowledge and assumes that knowledge is shared mainly through direct person-to-person contacts' (Desouza & Evaristo, 2004, p. 87). Similarly, the directories that point to where knowledge and expertise reside can either be codified (e.g. IS and IT) or personalized (e.g. personal memory or other people's memories). In other words, transactions between individuals take place through the use of various codified (e.g. databases) and personalized (e.g. theirs or other people's memory) directories. Such a TMS can be further developed and renewed through a constant update of these codified and personalized directories.

In line with such an approach, the following section addresses the challenges associated with knowledge transfer in globally distributed contexts from a transactive memory perspective.

KNOWLEDGE TRANSFER THROUGH TRANSACTIVE MEMORY: THE CHALLENGES

A TMS may offer various benefits to both teams and individuals. Through the development of a TMS and the awareness of 'who knows what', the performance of a team can be improved (Faraj & Sproull, 2000; Moreland & Myaskovsky, 2000). More specifically, a TMS may enhance specialization and division of labour. Teams and individuals could develop expertise in their own areas while being aware of the existence of expertise elsewhere (Majchrzak & Malhotra, 2005). In addition, the literature asserts the positive association of a TMS with team learning, speed to market, new product success (Akgun *et al.*, 2005), and an efficient coordination of expertise in teams through the development of similar labels and categories for encoding and retrieving information (Faraj & Sproull, 2000; Majchrzak & Malhotra, 2005; Nevo & Wand, 2005).

The development of a TMS can be facilitated through various activities. Past studies have illustrated the development of a TMS by studying the close relationships between couples (Wegner *et al.*, 1991). More recently, research has proposed that training activities contribute to the development of a TMS (Moreland & Argote, 2003). In colocated teams, the development of a TMS within a team seems achievable through sporadic training sessions and continuous problem-solving activities (Yoo & Kanawattanachai, 2001; Majchrzak & Malhotra, 2005).

However, several studies have raised concerns that developing a TMS may face significant challenges in distributed contexts (e.g. Majchrzak & Malhotra, 2005). For one, globally distributed teams often experience changes in membership that negatively affect the long-term development of a TMS (Ancona *et al.*, 2002). Furthermore, in many distributed settings, team members do not have any prior experience of working together. Their distributed mode of operation decreases communications and increases the possibilities for conflict (Armstrong & Cole, 1995), misunderstanding and breakdowns in communication (Cramton, 2001; Chudoba *et al.*, 2005). In teams that do not carry out joint training or arrange face-to-face meetings (Yoo & Kanawattanachai, 2001), the development of shared understanding is even more challenging because members of such teams do not stand on 'common ground' (Cramton, 2001). These challenges faced by distributed teams may hamper individuals' efforts to successfully maintain a system in which personalized directories are created and maintained. Furthermore, developing and updating a codified directory of information may be hampered by the adoption of different routines and methodologies across dispersed teams (Desouza & Evaristo, 2004) and by difficulties to standardize work practices across remote locations. This problem results in fewer opportunities to access knowledge by remote counterparts.

Table 1 reviews the meaning of encoding, storing and retrieving processes in the context of codified and personalized directories in globally distributed teams. We have developed these definitions and observations based on the existing literature of globally distributed teams, knowledge management and transactive memory, as discussed above.

We use transactive memory processes and definitions presented in Table 1 to explore how one software vendor transferred knowledge between onsite and offshore teams.

RESEARCH METHODS

Design and case selection

In line with past research (Eisenhardt, 1989; Yin, 1994), a case study method was selected for this research. An in-depth case study of globally distributed software development projects was carried out, and a qualitative, interpretive approach was adopted.

To analyse the role of transactive memory in knowledge transfer between members of dispersed teams our primary case selection criterion was to find globally distributed projects that were actively involved in knowledge transfer. Two projects from TATA Consultancy Services (TCS) were selected and studied in-depth in the context of transactive memory. The projects faced complex and challenging knowledge-transfer situations, as remote counterparts needed to transfer knowledge while co-developing and implementing the TCS Quartz financial platform for Scandia and Dresdner banks.

Data collection

Evidence was collected from interviews, project documentation and observations (Eisenhardt, 1989; Yin, 1994). Interviews were conducted at two remote sites: in India and Switzer-

Table 1. Transactive memory processes, codified and personalized directories in globally distributed teams (based on Wegner, 1987)

Memory process in a TMS (Wegner, 1987)	Types of directories in a TMS	
	Codified directories	Personalized directories
<i>Encoding</i>		
Having a shared 'cataloguing' system	Creating a shared system to categorize information. This can be effectively achieved by developing a set of rules of how to label the subject and location of the expertise.	Creating a shared understanding of context and work-related processes, terminology and language.
<i>Storing</i>		
The way in which the information is organized in physical locations and in the memories of dispersed team members	Storing information about the subject and location of the knowledge. This can be achieved by creating pointers to the location of knowledge in an expertise directory. Storing capabilities include up-to-date records of available documents and expertise.	Storing information about 'who knows what' and 'who is doing what' in individuals' memories
<i>Retrieving</i>		
(1) Knowing where and in what form information is stored in the dispersed team	Developing capabilities to find information necessary to coordinate expertise.	Developing interpersonal channels through which individuals can search for information about who has expertise and in which areas, and where this expertise resides
(2) Being able to find required information through determining the location of information, and, sometimes, 'the combination or interplay of items coming from multiple locations'	Includes search capabilities (e.g. keyword-based) for effective and efficient search and retrieval processes.	

TMS, transactive memory system.

land (for the Scandia Bank), and India and USA (for the Dresdner Bank). Interviewees were chosen to include (1) counterparts working closely at remote locations; and (2) diverse roles such as managers and developers. In total, 14 interviews were conducted. Interviews lasted on average 1.5 h; they were recorded and transcribed in full. A semistructured interview protocol was applied, to allow the researchers to clarify specific issues and follow up with questions.

Data analysis

Data analysis followed several steps. It relied on iterative reading of the data using open-coding techniques (Strauss & Corbin, 1998) to sort and refine themes emerging from the data (Miles & Huberman, 1994). In particular, six themes that represent the concept of *transactive memory* were carefully studied: *encoding*, *storing* and *retrieving processes*, each process in relation to

codified and personalized directories. Statements that were found to correspond with these six themes were selected, coded and analysed using Atlas.ti – Qualitative Data Analysis software (Miles & Huberman, 1994; Weitzman, 2000).

The first step in our data analysis aimed to examine *how transactive memory enables knowledge transfer in globally distributed teams* (the first part of the research question). It involved reading through the interview transcripts and collected documents, then (1) coding statements that illustrate different elements of a TMS, according to definitions presented in Table 1; and (2) marking evidence of knowledge transfer. During this stage chunks of text (paragraphs or sentences) describing (1) elements of a TMS and (2) evidence of knowledge transfer were coded. Next, statements (i.e. codes) illustrating elements of a TMS were grouped into the six above-mentioned categories that represent the six elements of a TMS.

Then, to address the second part of the research question – *through what mechanisms a TMS can be created and maintained* – we analysed statements in each of these six categories to identify specific organizational mechanisms that enabled TCS to develop and maintain a TMS for knowledge transfer in globally distributed teams.

THE QUARTZ PROJECT: KNOWLEDGE TRANSFER IN A GLOBALLY DISTRIBUTED TEAM

To understand the complexity involved in transferring knowledge between remote counterparts, we first elaborate on TCS and the challenges they faced in these projects. Following this, the results of the case study will be presented. To explore the role of transactive memory in knowledge transfer the analysis will be organized around knowledge-transfer challenges during encoding, storing and retrieving processes and the role that transactive memory has played in overcoming these challenges.

TATA Consultancy Services background

This study concerns the development and implementation of Quartz, an integrated financial platform aimed at providing solutions for financial institutions such as traditional and internet banks, brokerage/securities houses and asset managers. Quartz consists of a collection of architectural and business components that can be integrated with third-party components to provide a solution according to the requirements of a specific customer. The Quartz group (a unit within TCS) is running several Quartz implementations simultaneously, for different clients. A typical Quartz implementation included the integration of Quartz with a customer's system and its customization to suit the needs of a specific customer.

The project organization of a Quartz implementation consists of an *onsite* team at the customer location and *offshore* teams at the development centres of TCS for system development and front-end design (Figure 2). The majority of the Quartz team resided in one location throughout the project, either onsite or offshore, while only a small number of individuals travelled between remote locations for short visits. Teams at each site are headed by project lead-

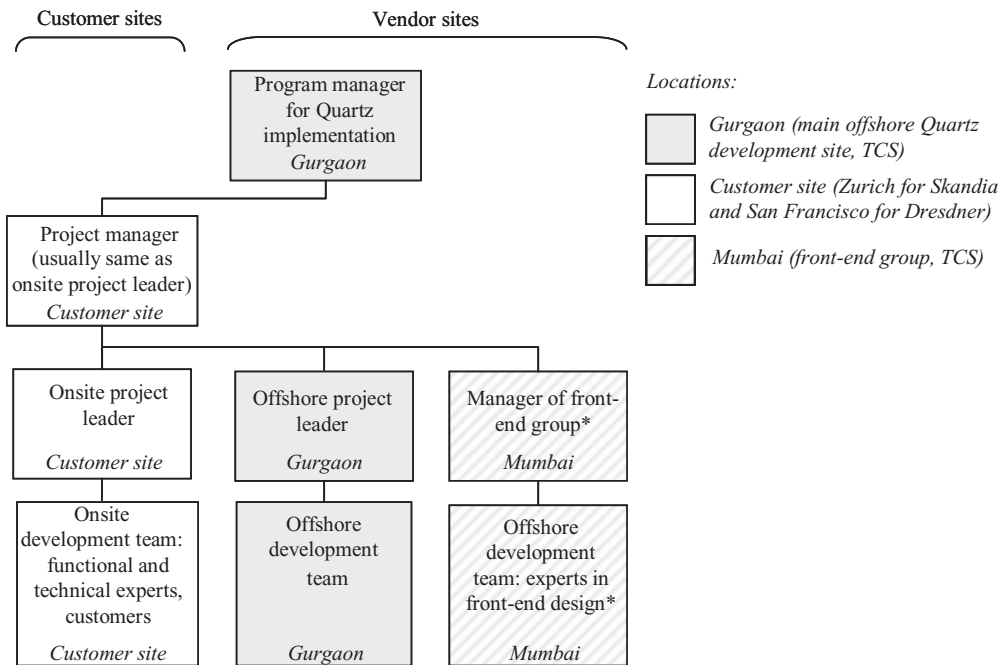


Figure 2. Organizational structure of the Quartz projects. *The front-end group was involved in the Skandia project; it was not involved in the Dresdner project. TCS, TATA Consultancy Services.

ers who report back to the project manager and ultimately the Quartz program manager. The following Quartz implementation projects are investigated: (1) Skandia Bank in Zurich; and (2) Dresdner Bank in San Francisco. Both projects are concerned with the implementation of Quartz, therefore they are analysed together as one 'embedded' case study (Yin, 1994): the two projects are subunits of analysis. In terms of global distribution, the Skandia development team was distributed across three geographical locations: two *offshore* teams in Gurgaon and Mumbai (India), and an *onsite* team at the customer location in Zurich (Switzerland). Furthermore, vendors of third-party components were located in different countries (more than 25 vendors in total). The Dresdner development team involved an *offshore* team in Gurgaon and an *onsite* team at the customer site in San Francisco (Figure 2).

The need for knowledge transfer

The philosophy TCS followed in dividing the work between the onsite and offshore sites was, whenever possible, to send work offshore to take advantage of the cost, quality and availability of offshore personnel. As one interviewee explained, the onsite team was sending requirements offshore 'because the expertise and major source code are here [offshore, in Gurgaon],

and mainly because of the expertise, it is quicker and easier to work here'. However, the majority of activities required close interactions with customer representatives through the onsite team. Activities during the initial project phases that required direct customer contact and access to the customer's site, such as user requirements and release management, were done onsite. Activities that required involvement of the client and close interactions among the TCS developers were conducted in a mixed onsite–offshore mode. Overall, the majority of the activities required ongoing bidirectional knowledge transfer between onsite and offshore teams. The only activities that were undertaken independently at the offshore location were coding and unit testing. Table 2 illustrates the knowledge-transfer flows and challenges per project phase as described by the TCS engineers. Knowledge-transfer challenges are identified (C1, C2, etc.) for further analysis.

In the next section, we focus on some specific knowledge-transfer challenges (from Table 2) to illustrate the way engineers at TCS dealt with these knowledge-transfer challenges through the creation, use and updating of codified and personalized directories. We discuss knowledge-transfer processes by examining encoding, storing and retrieving processes.

Knowledge transfer: encoding and updating codified and personalized directories

To overcome knowledge-transfer challenges, TCS had developed a memory system that ensured the flow of knowledge between the client, onsite and offshore teams. To achieve effectiveness from this memory system, encoding of the knowledge and updating of directories took place. This was done through a set of rules and standards (for codified directories) and by propagating common terminology, language and concepts that team members use on a daily basis (for personalized directories). The encoding process supported the transfer of knowledge between onsite and offshore by creating a catalogue of pointers to knowledge holders and knowledge seekers.

For example, one particular challenge is to transfer knowledge about customer requirements from onsite to offshore team (C2 in Table 2). In overcoming this challenge, onsite team members first codified customer requirements by summarizing them in writing, and following this the onsite team used a template document (e.g. Business Requirement Overview) to describe these requirements. More importantly, this template also encoded the subject and the location of this document. As members of the offshore teams were familiar with these templates and the Quartz terminology, they could locate the document, interpret customer requirements defined onsite (C2), and act upon them. One manager said:

We have set procedures for defining the requirements. If people follow the procedures, then the things become very easy to interpret or understand.

Similarly, during high-level design, to transfer knowledge from offshore to onsite about the prototype created offshore (C4), and to enable the onsite team to explain product specifications to the customer (C7), the offshore team encoded the subject and location of this knowledge using Business Requirement Specification templates and High Level Design Document templates. Onsite team members were familiar with these templates (the encoding scheme the

Table 2. Knowledge transfer during project phases

Project phases	Knowledge transfer from onsite (Zurich, San Francisco) to offshore (Gurgaon, Mumbai)	Knowledge transfer from offshore (Gurgaon, Mumbai) to onshore (Zurich, San Francisco)	Knowledge-transfer challenges
Requirement definition	Customer requirements		<ul style="list-style-type: none"> • Onsite team needs to capture all customer requirements (C1) • Offshore team should be able to understand correctly customer requirements as documented by the onsite team, i.e. definition and interpretation of requirements should be consistent between onsite and offshore teams (C2) • Offshore team members need to know who to contact onsite for different requirements if clarifications are required (C3)
Analysis and prototyping	Customer feedback on prototype design	Prototype design	<ul style="list-style-type: none"> • Onsite team should understand the prototype created offshore and be able to show and explain it to the customer, with minimum guidelines from the offshore team (C4) • Offshore team should be able to understand correctly customer feedback communicated in writing or verbally by the onsite team (C5) • Offshore team members need to know who to contact onsite for different issues that require clarifications (C6)
High-level design	Modified and signed specifications	Specifications	<ul style="list-style-type: none"> • Onsite team should be able to interpret product specifications created by the offshore team and understand how to address customer requirements (C7) • Offshore team should be able to identify quickly modifications made by the onsite team and interpret them correctly (C8)
Construction (Quartz configuration, coding and unit testing)	Not Applicable	Not Applicable	<ul style="list-style-type: none"> • Few challenges as construction is carried out mostly offshore
Integration and system testing		Actual system components and guidelines for integration and testing	<ul style="list-style-type: none"> • Onsite team should be able to understand functionality of the system components guidelines for system integration, with minimum guidelines for integration and testing (C9)

Table 2. cont.

Project phases	Knowledge transfer from onsite (Zurich, San Francisco) to offshore (Gurgaon, Mumbai)	Knowledge transfer from offshore (Gurgaon, Mumbai) to onshore (Zurich, San Francisco)	Knowledge-transfer challenges
	Change requests	Changes to the system and guidelines for their implementation	<ul style="list-style-type: none"> • Members of the onsite team may ask for clarifications and/or help with debugging from the offshore team: they need to know who to contact offshore for different issues (in particular, who wrote codes for different system components) (C10) • Offshore team members should be notified about new change requests (C11) • Members of the onsite team should be able to track the status of the changes they requested (C12) • Onsite team members should be notified when change requests have been implemented (C13) • Offshore team members should know who to contact onsite if clarifications are required and/or when changes have been completed (C14) • Onsite team members should be able to understand the essence of the change and what aspects of the system may be affected by the change (C15)
Release management (system roll-out and user training)	Questions, requests	Roll-out guidelines and training material	<ul style="list-style-type: none"> • Onsite team should be able to understand roll-out guidelines and how to use training material, with minimum guidelines and clarifications from the offshore team (C16) • Onsite team members should know who to contact for different issues / system components when they (or customer) have questions (C17) • Onsite team should be able to quickly identify modifications done by the offshore team and know how to implement them (C18)
		Clarifications, modifications	

templates are based on) and could easily locate the knowledge, understand the specifications created offshore and explain these to the customer. Furthermore, these documents specified the subject, and the name of the expert and his or her location, so that when a remote counterpart needed clarifications about this matter, he or she could easily locate the expert through this codified directory.

The use of standard templates to capture and transfer knowledge from onsite to offshore locations has created a cataloguing system that served as a codified directory in which pointers to where information resides have been mapped out. Among the templates that were stored in this cataloguing system were (1) procedural standards, such as the Quartz Implementation Methodology for the Quartz system; and (2) documentation standards that include (but are not limited to): the Project Documentation Set (Business Requirements Overview, Business Requirements Specifications, High Level Design Document, DB Design Document, Module Test Specifications and Product Acceptance Testing Specifications), and the User Documentation Set (Online Help, User's Manual, Installation Manual, Operations Manual). The update of this directory took place each time new information was placed in this directory. For example, when the customer wanted to add new functionality to the prototype design, the onsite team captured this request in Business Requirement Overview template (C5) and created a new entry to the codified directory. This new entry updated the codified directory for both onsite and offshore teams.

Knowledge-transfer challenges were also overcome through personalized directories by linking knowledge seekers with knowledge holders. For example, the Requirement Definition stage posed two knowledge-transfer challenges (C2 and C3 in Table 2) that the overcoming of which may also depend on the existence of updated personalized directories among members of the onsite and offshore teams. Properly understanding customer requirements (C2) and knowing who to contact at the onsite team with queries (C3) required the offshore team to develop an understanding of the onsite team composition and the respective area of expertise per individual. Personalized directories as such offered an alternative route to the codified directory to transfer knowledge between onsite and offshore teams. Put simply, the constant interactions between onsite and offshore team members created and updated directories that were based on personal memory or other people's memory and that categorized personal experiences (what person A knows) and assigned 'labels' as to what other people know (what A knows about B) and what they know about what other people know (what A knows about what B knows about C). To arrive at such a personalized directory system and to support the development of common patterns for encoding personal knowledge about oneself and other people's knowledge, TCS introduced various activities to encourage interactions between remote counterparts and facilitate shared experiences, shared understanding of the design and the use of common terminology and language. As a first step towards bringing people together and developing a shared understanding of the product, a joint Quartz training program was introduced, compulsory for all employees joining the Quartz group. This program included introductory training during which new employees received an overview session of the Quartz platform and its components, learned about standard Quartz implementation methodologies and were introduced to the terminology used in this project. In addition, newcomers learned the basics of the programming language which was used to develop the Quartz platform. This training provided the basis for common encoding of information in personalized and codified directories that, in turn, improved understanding and created a basis for efficient knowledge transfer between future remote counterparts. For example, as one team leader described it:

We all speak Quartz language. It is a loss for us if somebody leaves Quartz because for somebody new it will take time to learn Quartz.

Additional training programs were introduced in later stages of the project during which engineers were encouraged to develop their own expertise in one functional area of Quartz. This facilitated the development of mini-teams: although not colocated, each team still shared a specialized functional area and a similar understanding of that particular function. Furthermore, as stated earlier, some team members were rotated between onsite and offshore locations to increase face-to-face interactions between remote counterparts and to promote learning and the development of shared expertise between dispersed teams.

For members of globally distributed teams, updating personalized directories involves updating 'what they know' and 'what they know about what others know'. In terms of updating 'what they know', this had mainly relied on individuals encoding new experiences (e.g. about new product functionality) in their memory using 'labels' based on the Quartz terminology, standards and values. Because of the lack of face-to-face and informal interactions between onsite and offshore teams, updating 'what they know about what others know' had mainly relied on regular teleconferences and short visits to remote locations by project leaders and some team members.

Knowledge transfer: allocating and storing information through codified and personalized directories

While the encoding process is important to overcome knowledge challenges through the development of a cataloguing system, the storing process is imperative for knowledge transfer between onsite and offshore teams because of the risks involved in passing information between onsite and offshore. In such knowledge exchanges there is risk that information will be lost or dispersed in several locations. The storing process, in this regard, ensures the consistent allocation of information according to specific rules (e.g. information organized based on project stages) or according to expertise (information is transferred based on area of expertise). For example, feedback provided by the customer about the prototype design should be captured by the onsite team and transferred to the offshore team (C5 in Table 2). In this process, the TCS onsite team codified the feedback provided by the customer. Indeed, to ensure a consistent storing process, most of the documents used by the Quartz team to capture and codify knowledge were in a digital format and were available from one central location. To transfer this knowledge to the expert offshore, two storing processes were possible. First, the member of the onsite team relied on his or her personalized directory to allocate the appropriate expert in the offshore team who should receive this information. The second storing process involved a codified directory, in the form of a database (e.g. project repository), which served as an intermediary holder for the knowledge prior to it being retrieved by the offshore expert. The codified knowledge was stored in an intermediary location, labelled according to the subject matter and the location of the expertise involved until the offshore team accessed this object and retrieved this information. Often, the transfer of knowledge was enacted through

the use of both personalized and codified directories, i.e. storing the codified knowledge in an intermediary location and placing a call to the offshore expert, so that the effectiveness of the memory system was improved.

To ensure that members of the Quartz project used these documents in a consistent manner, i.e. could access, modify and store documents created by either the offshore or onsite teams, TCS have standardized the tools and methods used across remote locations. One manager explained:

In a distributed development environment, we need to clearly identify the quality processes to be followed and ensure commonality in the compliance of such processes. For example, common processes and tools for bug tracking, configuration management, release management, impact analysis, change management.

Indeed, through the standardization of tools and methods, TCS ensured the compatibility and the 'integrability' of files, components and applications developed and used at remote locations. Such standardization supported the storing process because understanding 'who is the expert' and 'whom this knowledge should be allocated to' was commonly communicated and understood. Indeed, when an offshore team transferred knowledge about system components to the onsite team during the integration, the onsite team, we have learned, encountered almost no problems in taking over the integration, with minimum guidelines required from the offshore team (C9). The codified directory was constantly updated since the source code and various project documents were replaced by the new versions, creating new labels and pointers to knowledge holders within the team.

Knowledge transfer also benefited from the application of personalized directories during the storing process. In this regard, members of the onsite and offshore teams enhanced their acquaintance with the pool of expertise available within the project through a division of work based on expertise. One engineer described this process:

We [onsite and offshore teams] work in parallel: we send them the source code and they integrate it into the infrastructure before delivering it to the client [. . .] I'll check out our source code and send the code to the onsite team to work on it. Then they send the changed code back to me and I'll check it in.

One manager reiterated this point:

Between us [offshore] and our onsite team we say 'we'll do this portion of the job because we have more competent people here who can look at this part, and then you can look at that portion of the job'.

Through this systematic approach to the division of work, TCS ensured that knowledge is stored in dedicated storage locations (personal memories of individual team members). Activities generating new knowledge and developing new expertise were allocated to specific team members based on their present expertise or management's attempt to develop new expertise in the particular area. By basing the division of work on expertise, TCS encouraged individuals to interact and establish links with other remote counterparts who shared a similar functional

specialization. In addition, TCS utilized Centres of Excellence in various functional areas and technologies to disseminate expertise and bring expertise to where and when these were needed. Through such mechanisms, remote counterparts developed an understanding of the area of expertise in each remote location, which in turn assisted them to trace experts during the knowledge-transfer process. Indeed, members of a dispersed project contacted remote counterparts to inform them about changes and share with them 'experiences' related to the design process. In this regard, members of onsite and offshore teams used their counterparts as 'storage' for personalized experiences, in which each member 'stored' in his or her memory experiences relating to the area of expertise that the entire team had accumulated during the project. One manager explained:

Each and every team member is aware of nearly all the things which are happening, the whole team has a basic knowledge about everything.

Through frequent interactions between onsite and offshore teams, remote counterparts continuously updated information in their personal directories about what others know and what others do, which enabled remote team members to know whom to contact during knowledge-transfer processes.

Knowledge transfer: coordinating the retrieval process through codified and personalized directories

To deal with some of the knowledge-transfer challenges described in Table 2, the retrieval of knowledge required the application of search mechanisms to locate who held the knowledge and where, using codified and personalized directories. Such a retrieval process can successfully be achieved when the information is previously encoded and stored properly. For example, during integration and system testing, members of the onsite team may need to ask for clarifications and get help from the offshore team. In this specific project, the TCS onsite team needed to know whom to contact (C10). To overcome this knowledge-transfer challenge, the onsite team could search the codified directory for experts who were involved in developing this particular code. This information was stored in the codified directory as part of the encoding and storing processes.

In addition, a central project repository was implemented to streamline the retrieval of information between onsite and offshore locations. For example, we have learned that during integration and system testing, an onsite team placed Change Requests into a Web-based system (C11). These Change Requests were automatically assigned to the offshore team who notified by email about the additional customer requirements. The offshore team retrieved this information through the Change Request system and implemented the change. Following the completion of the change, the offshore team logged the solution and made the changes implemented accessible to the onsite team (C13). During the critical stages of system integration, this retrieval process allowed the transfer of critical information between onsite and offshore teams, based on the labels created in the encoding and storing processes, during the critical stages of system integration.

Nonetheless, in some situations when help from remote counterparts was urgently needed (e.g. C10: bugs fixing during acceptance testing), remote team members mainly relied on their own knowledge of 'who knows what' recorded in their personalized directories to speed up the knowledge-transfer process. The utilization of personalized directories for retrieving processes was mainly promoted through the coordination and integration of expertise across the various sites. In addition to familiarizing remote counterparts with the existing expertise in other locations and developing an expertise-based system for the division of labour, TCS invested in various mechanisms such as Centres of Excellence and a computerized expertise system that allowed for searching for specific expertise among all TCS employees and that brought expertise together when it was needed. In this regard, the retrieval of personalized knowledge and the notion of personalized directories had evolved through expertise coordination and integration activities. Aspects that were critical for coordinating expertise revolved around time-zone differences and the notion of knowing 'who is doing what'. Indeed, members of the Quartz team indicated that it was common to contact remote counterparts at any time of the day. Flexible working hours even further supported person-to-person interactions for information retrieval despite time-zone differences. For example, one manager illustrated their communication patterns:

Within Quartz we can actually call up anybody whom we know at any point in time to get some assistance, even if we don't know somebody, if he's recommended by someone else, then we can call up and get assistance immediately.

Bringing in the needed knowledge to quickly solve problems also relied on the expertise-based division of labour that TCS had implemented across its onsite and offshore locations. Other mechanisms were put in place to coordinate the retrieval of information and to update personalized directories. For example, the management introduced various meetings and review sessions to familiarize and refresh the memory of team members with regard to 'who is working on what'. One interviewee described the implications of this approach:

It's not that only one person can do a job, otherwise, if one person doesn't come in, we won't be able to work without him/her. So we try to overcome this by making each and every team member aware of nearly all the things which are happening.

Lastly, onsite and offshore teams maintained a high degree of communication by phone, up to three or four times a day, which further assisted in keeping updated the notion of 'who is working on what'. Issues discussed during these conference calls, as observed, revolved around progress updates, handover of work from one team to another when a working day had ended, and clarifications with regard to changes and design problems. One engineer, describing the implications for transferring expertise within the team, explained that:

When a project is being established, proper ground work includes that everything should be conveyed and project information is shared among team members. [. . .] Each and every team member is aware of nearly all the things which are happening, the whole team has a basic knowledge about what others do.

As a result of these communications, interviewees claimed that they developed a better understanding of the team composition in a remote site and the areas of specialties that each member covered. This promoted knowledge transfer at various stages of the project.

DISCUSSION

In current IS research, transactive memory is gaining ground as a powerful analytical concept (e.g. Yoo & Kanawattanachai, 2001, Akgun *et al.*, 2005). However, the implications for knowledge transfer have hardly been explored, particularly in the context of distributed teams. Therefore, the objective of this paper was to investigate *how transactive memory enables knowledge transfer in globally distributed teams, and through what mechanisms a TMS can be created and maintained*. Through a transactive memory perspective, we studied knowledge transfer between offshore teams in India and onsite teams in Western Europe and the USA.

Indeed, as Table 2 conveys, globally distributed teams involved in offshoring activities face various knowledge-transfer challenges. Furthermore, the transfer of knowledge between the customer, onsite and offshore teams almost always involves the codification of the knowledge prior to transferring it. This approach to knowledge, as described in the case above, is an attempt to overcome geographical distances between onsite and offshore teams and to enable the transfer of work from more costly onsite locations to the cost-effective offshore locations. However, such a codification of knowledge may increase the misunderstandings and errors involved in the transfer of knowledge because of local contexts, routines and different skill and expertise levels between the customer, onsite and offshore teams. The Quartz case suggests that the standardized routines propagated by TCS assisted in creating memory systems that constantly update codified and personalized directories, enabling directory sharing regardless of the physical location of the teams, and offering multiple channels to effectively retrieve information when needed (Wegner, 1995). More specifically, standards, guidelines and templates were developed to enable systematic encoding of the subject and location of the information to be exchanged between these teams. This information was allocated to individuals through an intermediary object (e.g. project repository and tools) that, in turn, supported the transfer of codified knowledge between onsite and offshore teams. While common methods for storing enabled compatibility and exchangeability of codified knowledge regardless of the geographical location and local contexts, search capabilities and the use of messaging to inform individuals about the relevant information available in knowledge bases were central in supporting the retrieval of codified knowledge.

The development of personalized directories, on the other hand, relied on individuals' knowledge of who knows what, and their engagement in interpersonal processes disclosing personal knowledge bases to others. Indeed, the Quartz project teams developed patterns for encoding, storing and retrieving knowledge in the sense of a common language (Barinaga, 2002) and common patterns of communication. These were initially built through socialization and training. During later phases of the projects, the personalized directories were further

developed through the division of work based on expertise, job rotations and regular communications.

From a social constructionist viewpoint (e.g. Lave & Wenger, 1991), the Quartz's personalized directories mainly relied on the continuous development, management and coordination of expertise that supported encoding, storing and retrieving processes. Similarly, Orr (1990) has demonstrated how collective expertise could be developed through story-telling in a collocated environment. In this regard, personalized directories, that are 'developed communally, over time, in interactions among individuals in the group' and that 'exists more or less complete in the head of each group member who has been completely socialized in the group' (Leonard & Sensiper, 1998, p. 121), may offer opportunities to remote counterparts to develop, manage and coordinate the collective expertise of the entire team through encoding, storing and retrieving activities.

First, in the Quartz case, the encoding of project and product knowledge facilitated the development of collective expertise. Indeed, the initial Quartz training program for the entire global team facilitated the development of common terminology and understanding related to product development, project management and collaborative processes. Through these training activities, members of the Quartz project team negotiated the meanings of various technical and administrative aspects involved in the project, devising a procedure for future engagement (Wegner, 1987). In a later stage, short relocations and daily communications between onsite and offshore sites offered new opportunities to renegotiate procedures and redefine the terminology used by the team.

Second, the storing of knowledge enabled the management of collective expertise. This was mainly achieved through an expertise-based division of work. This approach to division of work resulted in the creation of multiple distributed teams consisting of like-minded experts who remotely collaborated on a particular aspect of the project (Evaristo & van Fenema, 1999). As part of their personal development and through their participation in problem-solving activities, members of these expertise-based distributed teams relayed stories to remote counterparts (Lave & Wenger, 1991). By negotiating the meaning of these stories, an understanding of 'what A knows about what B (i.e. a counterpart) knows' emerged for A. This understanding assisted members of the expertise-based distributed teams to locate the most appropriate members, who share the same meaning and context, for future 'storing' activities. In this way, members of the distributed team manage their knowledge of the expertise available within the team.

And third, through the retrieval of the knowledge the coordination of collective expertise within the distributed team is made possible. In retrieving knowledge, members of the team coordinated the transfer of knowledge needed for problem solving. Indeed, retrieving information requires knowing 'where expertise lies' (Faraj & Sproull, 2000). The development of the meta-knowledge described above supported members of the expertise-based distributed teams when they (re)approached counterparts to 'retrieve' knowledge. The retrieval of knowledge was largely enabled by the shared meaning and context that these teams developed throughout the project, supported by virtual and face-to-face meetings, and short visits.

We further argue that the three transactive memory processes, i.e. encoding, storing and retrieving, play different roles in knowledge transfer. First, the development of collective exper-

tise, i.e. encoding, acts as a process for defining the procedure through which knowledge will be transferred. During the encoding, parties negotiate the meaning of knowledge (i.e. the subject and location of the knowledge) following either a codified, standardized approach or by relying on an embedded routine developed within the organization. Second, the management of expertise, i.e. storing, creates a pointer to the location where the knowledge is stored and from which it can later be transferred. In this regard, creating a pointer involves the actual storing activity during which A and B (following Figure 1) attach particular labels to the knowledge stored within A, B or elsewhere. These labels – including, for instance, contextual information – make it possible to negotiate and clarify the meaning of this information, and its subsequent retrieval from its place of storage. And third, the coordination of expertise, i.e. retrieval, concerns the integration of knowledge by bringing together experts through search mechanisms and interpersonal contacts. For knowledge transfer to take place, teams rely on the one hand on the procedures and shared meanings established through encoding processes, and on the other hand, on interpretation and the use of labels attached to the transferred knowledge during the storing process. The coordination of expertise – and thus knowledge transfer – can be supported by relying either on the codified or personalized directories or both.

The question that we may pose at this juncture is: to what extent do personalized or codified directories matter to knowledge transfer? We claim that it would be wrong that either of these memory systems would be perceived as 'better' or 'worse' for knowledge transfer. In line with Cook & Brown's (1999) observation on epistemologies of knowledge, we argue that codified and personalized directories are best seen as two complimentary, rather than competing, memory systems (Sorensen & Lundh-Snis, 2001). Furthermore, the findings of this study provide insights into how the two types of directories interact. They do not operate in isolation or as substitutes. Absence of the codified directories would deprive the teams of shared methods for encoding, storing and retrieving information, which may strain the personalized directories beyond feasibility. Leaving out the personalized directories, on the other hand, for instance, due to high personnel turnover rates, would leave the project with independently working individuals who would find it difficult to agree on collaboration standards (Cramton, 2001).

These insights lead to a conceptual question: how to theorize the interplay of codified and personalized directories? We suggest that groups develop meta-routines (Moorman & Miner, 1998) that interlink the two types of directories. In this regard, there is a 'generative dance' (Cook & Brown, 1999) between these two memory systems that contributes to the transfer of knowledge between A and B. The codified directories depend on interpersonal 'norming' processes for defining standards, templates and procedures. The personalized directories extend the codified system by offering additional avenues in cases when documents provide incomplete knowledge about a task. In these cases, individuals know whom to contact and how to retrieve information. Evidently, the development and use of a TMS may change over time. During initial phases of the project, rudimentary parameters of transactive memory are defined (e.g. which sites and individuals are responsible for which tasks and knowledge domains). These are extended and refined when people work together over prolonged periods of time, renegotiating meanings and regenerating learning around the knowledge-transfer process.

Table 3. Organizational mechanisms and processes supporting the development of a TMS in globally distributed teams

	Codified directories	Personalized directories
Encoding/updating directories	<ul style="list-style-type: none"> • Standard document templates (for product deliverables and process phases) • 'Glossary of terms' to include unique (e.g. product-specific) terminology 	<ul style="list-style-type: none"> • Rotation of onsite and offshore team members • Joint training programs • Team building exercises • Social activities
Storing/allocating information	<ul style="list-style-type: none"> • Central project repository • Standardization of tools and methods across locations • Centralization of tools on the central server, Web access 	<ul style="list-style-type: none"> • Expertise-based division of work • Creating complementary documentation for software components (includes the name of the developer)
Retrieval coordination	<ul style="list-style-type: none"> • Standard process procedures (to include pointers to the location of information) • Keywords-based search capabilities • Tools that enable automated notification of changes and requests (e.g. Software Configuration Management and Change Management tools) 	<ul style="list-style-type: none"> • Systematic and frequent communications using email, tele- and video-conferencing • Technologies that enable reachability when on the move and out of working hours (e.g. mobile phones, pagers, PDAs)

TMS, transactive memory system.

In terms of the organizational mechanisms that create and maintain a TMS in a distributed context, we claim, based on the case reported above, that a TMS can be developed and maintained in order to support knowledge transfer through the propagation of certain rules and standardized work routines that can overcome differences in local contexts, skill levels and work routines. While such standardization also derives from an increased standardization in software development, evidence from the Quartz case suggests that TCS capitalize on this recent trend to offer remote counterparts a memory system through which knowledge can be exchanged. For example, the standardized templates that were used by the onsite team to capture customer knowledge were designed with the thought in mind that these would also be a pointer to where this knowledge resides. Other organizational mechanisms directed at offering remote counterparts opportunities to expand their personalized directories were also implemented. The rotation of team members, the expertise-based division of work that encouraged interactions between onsite and offshore teams, and frequent teleconferences, are only some of the mechanisms supporting the development of a TMS as an enabler for knowledge transfer. Table 3 outlines these organizational mechanisms based on the three main processes in a TMS.

IMPLICATIONS

What implications does this study have for research and practice? From a theoretical perspective, this study advances understanding of knowledge transfer in distributed contexts and offers

linkages to the concept of transactive memory. While the literature on knowledge transfer is extensive, little is known about the challenges involved in transferring knowledge between the customer representatives, onsite and offshore vendor teams. In addressing this gap, this paper outlined specific knowledge-transfer challenges involved in the Quartz implementation project and explored through the lens of transactive memory how these teams transferred knowledge and overcame different local contexts, work routines and expertise levels. Indeed, the few studies that had explored the concept of transactive memory in distributed teams provided little insight, if any, into the possibilities to improve knowledge-transfer processes through the development of a TMS. In particular, past research paid little attention to the possibility that transactive memory might act as an enabler of knowledge transfer in distributed teams. In addressing this gap, this study has illustrated how transactive memory supports knowledge transfer between onsite and offshore locations. Furthermore, by unpacking the concept of transactive memory and presenting two types of directories, namely, codified and personalized, this study extends the discussion about the elements that constitute a TMS in an organization. For instance, we extend the IS literature, which so far has somewhat downplayed the role of personalized directories and has often focused on codified directories in the context of distributed environments. In exploring the way knowledge was transferred between onsite and offsite locations, an array of processes and mechanisms associated with the personalized directories emerged. Furthermore, by offering a link to the development, management and coordination of collective expertise, this study emphasizes the role that collective expertise plays in knowledge-transfer processes.

From a practical viewpoint, we argue that in order to enable the transfer of knowledge between remote sites, organizations should consider the mechanisms reported above that support the development, management and coordination of collective expertise, and enable the transfer of knowledge between onsite and offshore teams. In doing so, managers should consider two key aspects with respect to work division. First, they should attempt to select project members based on their shared histories of collaboration in their respective area of expertise. In doing so, remote counterparts know each other, have already developed a meta-knowledge relating to their counterparts and have established procedures for engagement. Such teams will tend to focus on renegotiating and (re)clarifying meaning about knowledge-transfer procedures and contexts. Such a staffing approach is likely to speed up the development of the TMS, as procedures, codified routines and social ties have already been established. Second, an expertise-based division of work should be considered when members of the team have worked with each other before and have developed shared histories. Teams that do not have shared histories, however, may benefit from a division of work that is based on geographical location for a period of time, which enables this team to establish procedures, standards and templates from the development of its codified directories, before changing to an expertise-based division of work approach.

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