The Role of Negotiation Objects in Managing Meaning Across e-Collaboration Systems

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Abstract

This paper examines the ways in which negotiation objects – objects used for boundary-spanning, bridging, or brokering purposes – mediate productive breakdowns in collaboration across distributed organizational workgroups. Objects are increasingly displacing direct social relations in the mediation of distributed work. When collaboration between organizational groups is virtually-mediated, the "management of meaning" that used to be centralized in strategic managers is distributed. In collaborating around virtually-mediated knowledge objects, various groups compete to define the meanings attached to those objects, in order to define the importance and legitimacy of various forms of organizational knowledge and thus control organizational roles, structures, and processes. This study analyzes how representational, technical, and organizational resources provide a mediation of knowledge and influence between different work-groups and how different forms of negotiated mediation lead to the adaptation of the information systems that collaborating workgroups define and use in common. It examines the mediating role played by various forms of "negotiation object," to reach a new understanding of how e-collaboration systems evolve in practice.

INTRODUCTION

Firms are increasingly making use of information systems (IS) to support collaboration across organizational units, using cross-functional and enterprise systems to coordinate wide-ranging business processes. Integrating diverse sources of expertise to manage and access knowledge across organizational boundaries is a key organizational competency (Levina and Vaast, 2005). But establishing a common vision for the scope and impact of boundary-spanning information systems is problematic. This scope of organizational change requires the resolution of "wicked" problems, which are socially-constructed and unbounded: thus there are no clear criteria for their resolution, nor clear methods for resolving differences in stakeholder perspectives (Rittel and Webber, 1973). The distributed operations of contemporary organizations involves a diverse set of actors who must coordinate their work and collaborate in sharing knowledge across the boundaries of traditional work functions and business units. The deep problems that domain- or discipline-specific, “specialized” knowledge poses to organizations are most evident at the boundaries between organizational units and functions (Carlile, 2002). We lack ways to share knowledge across functions and domains and we find it increasingly difficult to understand what knowledge is significant for effective collaborations, because of the situated and socially-embedded nature of this knowledge and the lack of a common “language” for stakeholders from multiple domains. As a result, enterprise-level and other boundary-spanning information systems may be inappropriately designed, failing to integrate information-flows or to coordinate work across “islands” of local and emergent knowledge (Markus et al., 2002).

These constraints lead to the a key role for managers and other thought-leaders in distributed organizations: the management of meaning across functional and workgroup boundaries. Much attention has been paid to how organizational actors make sense of their social environment, collaborating in constructing joint frameworks for interpretation (Choo, 1996; Weick, 1995).

Less attention has been paid to the management of meaning in distributed organizations. Transformational leadership lies as much in framing reality for others as it does in providing direct guidance:

> " Formal organization thus embodies at least two distinctive, yet complementary aspects of the phenomenon of leadership: (I) the structure of organization institutionalizes the leadership process into a network of roles, often in an overconcretized and dehumanizing form; (2) mediating or interpersonal leadership-what is most evident as leadership in action, operationalizes the principles of leadership as an emergent process within the context of the former. This is usually as a means of transcending the limitations of the former for containing the dialectical tension that it embodies, and as a means of giving the whole coherence and direction over time. " (Smircich and Morgan, 1982).

As organizational work becomes increasingly mediated by virtual technologies, this provides an opportunity for boundary-spanning thought-leaders to frame the reality of work for others. Organizational leadership may be conceived in terms of knowledge generation, focusing on the negotiation of architectural knowledge – knowledge which enables various groups to collaborate across boundaries (Balogun and Jenkins, 2003). However, the formal leadership perspective that accompanies a focus on architectural knowledge is a poor fit with the emergent knowledge processes that characterize boundary-spanning work in contemporary organizations (Lamb and Davidson, 2000; Markus et al., 2002). Work in distributed organizations ends to be virtually-mediated, requiring a focus on negotiation objects: objects that permit the meanings of shared work practices and goals to be negotiated across workgroups and business units. The kind of work practices involved in addressing nonroutine problems is differentiated – across participants and across work boundaries. This makes the objects used in collaboration more capable of creating a disassociation between subject and object, providing the basis for reflection about organizational meanings and an opportunity for constructive change (Knorr Cetina, 2001).

This study analyzes how representational, technical, and organizational resources provide mediation of knowledge between different work-groups and how different forms of negotiated mediation lead to the adaptation of the information systems that they define and use in common. It examines the mediating role played by various forms of "negotiation object," to reach a new understanding of how e-collaboration systems evolve in practice.

CONCEPTUAL BACKGROUND

LEADERSHIP IN DISTRIBUTED ORGANIZATIONS

The dominant perspective on distributed cognition in the IS literature conceptualizes knowledge at the boundary between communities of practice as embodied by technical systems such as shared databases or workgroup coordination applications (Hollan et al., 2002; Hutchins, 1995). A distributed form of group memory, transactive memory, accumulates through interactions between individuals. Transactive memory involves two elements: information about the areas of knowledge and skill possessed by each group-member (domain-expertise), and information about the location of knowledge (who-knows-what) (Wegner, 1987). Computer-supported transactive memory systems enable group-members to benefit from each others' knowledge if they can formalize their understanding of who-knows-what (Hollingshead and Brandon, 2003; Moreland, 1999).

An alternative perspective accounts for the role of human agency in boundary-spanning collaboration. Conjoint agency is mediated by a variety of actors, practices and objects that support bridging operations in different ways: generating stories and metaphors that define shared value-systems and goals (Pettigrew, 1990), employing human boundary-spanners who

reconcile multiple frameworks for action (Engeström et al., 1995), or leveraging boundary objects that are plastic enough to be interpreted as informational items in different ways by various groups but convey sufficient common meaning for collaboration across boundaries (Carlile, 2002; Star, 1989) IT systems may act as boundary-objects (Levina and Vaast, 2005), as may cognitive artifacts such as group to-do lists, that are produced collaboratively to coordinate work-practices across domain-boundaries (Henderson, 1999; Hollan et al., 2002; Hutchins, 1995; Norman, 1991). The key element of this view of distributed cognition is that artifacts do not embody any cognitive rationale or basis for coordination without the key element of human interpretation. This is where the management of meaning becomes critical in driving boundary-spanning collaboration.

Transformational leadership has long been associated with manipulation of an organizational culture to frame reality for others (Pettigrew, 1985; Schein, 1985; Weick, 1987). This is achieved through the "management of meaning," where leaders bracket and frame organizational experiences to provide a context within which such events may be interpreted by the wider group of organizational actors. Leaders and other boundary-spanners generate stories and metaphors that define shared value-systems and goals (Pettigrew, 1990) and provide shared frameworks for action across multiple socio-cultural contexts (Engeström et al., 1995). This provides a framework within which current and future action can be situated (Smircich and Morgan, 1982). A parallel stream of research in communication theory has focused on the coordinated management of meaning, which provides a shared grammar, or common language for the public debate of contentious issues. Unless such debates are facilitated effectively, meanings are shaped by those with most power in the situation, who can provide the most influential voices in a debate. For meanings to be co-constructed, those with less influence must be provided with a mediating channel by which meanings can be negotiated (Pearce and Pearce, 2000). This influences who shapes emergent knowledge processes. Markus et al. (2002) argue that the design of emergent knowledge processes is best achieved by the inclusion of distributed sources of expertise and the ability of work systems and roles to evolve as experience is gained. This is set against the leadership role in formal organizational structures, whose raison d'être is to define and manage static work systems and roles (Horner, 1997).

This constraint is reduced in virtually-mediated organizations. Organizations increasingly rely on distributed human agency to provide the interpretive structures that support global management decision-making and leadership (Carlile, 2004; Engeström et al., 1995). Increasing virtuality in organizations appears to be associated with decreasing bureaucracy and decentralization of operational processes, with a selective centralization of some strategic management processes (Travica, 1998). But little is known about why this should be so, or what mechanisms manifest leadership in such situations. Is the leadership of technology-mediated, geographically and functionally diverse groups different? Knowledge creation and sharing in organizations is most often assumed to involve direct interactions between people (Suchman, 1998). But in distributed, virtually-mediated systems of work, polycontextual IT systems and other forms of boundary object facilitate distributed leadership (Levina and Vaast, 2005). The coordination of work around virtual objects such as information systems collaboratively produced documents, data or knowledge bases, or models of organizational processes and outputs is increasingly displacing direct social relations.

BOUNDARY-SPANNING COORDINATION

The unit of analysis in this study is the "community of practice" (Brown and Duguid, 1991; Lave and Wenger, 1991). A community of practice involves a group of interdependent participants, who develop a work context within which members construct shared identities and a shared social context that makes both work practice and identity meaningful. Such situated practice creates barriers to understanding between the various communities of practice that constitute the organization (Brown and Duguid, 1994). Thus, knowledge cannot be understood independently of the local context of its application and it cannot be understood independently of the shared practices in which the local community of practice engage. Members of a community of practice share not only a common understanding of what activities are required to achieve a specific end, but also a common perception of how those activities should be performed. These perceptions are often implicit and inseparable from the local context within which the community of practice operates (Lave and Wenger, 1991).

Groups of people who regularly work together on collaborative tasks develop a repertoire of *shared* understandings, that provide cognitive "shortcuts" – metaphors, common language and ways of doing things. These enable them to share common meanings (for example, "why we do it this way") without the need for complex explanations (Boland et al., 1994; Cook and Brown, 1999; Weick, 1995). This perspective-sharing requires not only shared knowledge, but also a shared system of norms, behavior, expectations and (inter-) personal identities that indicates why a specific term or way of performing a task is significant (Brown and Duguid, 1991; Lave and Wenger, 1991; Weick, 1995). Organizational knowledge is embedded within a local system of socio-cultural values that make sense of "how we do things here":

> "Knowledge and understanding (in both the cognitive and linguistic senses) do not result from formal operations on mental representations of an objectively existing world. Rather, they arise from the individual's committed participation in mutually oriented patterns of behavior that are embedded in a socially shared background of concerns, actions, and beliefs." (Winograd and Flores, 1986, page 78) .

Belonging to a community of practice involves mutual engagement in a joint enterprise, using a shared repertoire of resources to exchange knowledge. Such resources include speech acts, routines, documents, and other socially-constructed elements of work (Lave and Wenger, 1991; Suchman, 1998). As individual actors belong to multiple communities of practice, their multiple memberships provide a mediating mechanism that permits the spanning of boundaries between these communities. For example, a local unit's IS support person belongs both to the IS department community of practice and to the business unit community of practice. Definitions of "valid" and "relevant" knowledge become subject to negotiation and joint improvisation (Brown and Duguid, 1994; Carlile, 2002). So a key requirement of collaboration across communities of practice s to employ mechanisms that permit individuals to bridge the frameworks for action employed by each community: how organizational goals are interpreted and the meanings ascribed to work practices in the context of local, socio-cultural norms. Within this framework, boundary-spanning collaboration can be conceptualized in terms of three types of mediation:

- Boundary-spanning knowledge coordination, which involves negotiated sensemaking within an organizational information ecology;
- Bridging operations, which involves the negotiation of the socio-cultural framework which governs work processes and roles;
- Brokering activities, which mediate influence and power across organizational groups.

Boundary-Spanning Knowledge Coordination

Theories of distributed cognition argue that understanding is "stretched over" and coordinated between people and the knowledge-resources that they use (Star, 1989). Individuals coordinate their work through intersecting role-definitions that define how they interact and exchange information, coordinated through the use of shared artifacts and information-systems. Experts from various knowledge-domains act as *boundary-spanners*, translating the meaning of knowledge-resources in one community to the conventions used by another (Carlile, 2002). Boundary-spanners must adapt knowledge across multiple domains of application by means of their extensive knowledge of various groups' frameworks for action. A local group's framework for action includes an understanding of norms of behavior, frames the way that problems are conceptualized, and dictates legitimate forms of social relationship -- for example, associating with groups that are politically allied with the local group and limiting knowledge shared with members of non-allied groups (Engeström et al., 1995; Lave and Wenger, 1991; Weick, 2001). This type of tacit knowledge-resource is not amenable to codification or externalization. Its translation relies on "bridging operations", interlocking work-routines and shared interpretations of how work should be done, that span organizational boundaries. These are constructed and adapted through repeated interactions with actors from other domains.

Bridging Operations

Bridging operations translate local knowledge into a tacit form of generalizable knowledge, so that people can act automatically rather than engaging in prolonged deliberation every time a decision needs to be made (Weick, 1995). While intersubjective (cognitively shared) meanings result from shared, sociocultural interpretations of the work activity within a community of practice, Weick argues that the process of organizing - establishing and formalizing the webs of "interlocking routines and habituated action patterns that allow substitutability between" human actors in organizations bridges the gap between knowledge domains (Weick, 1995, page 74). Bridging operations translate local knowledge into global knowledge through communication and other interactions that relate work practices and interactions within the local workgroup to global organizational forms and procedures, or to new forms of knowledge that are only meaningful at the boundary between groups (Carlile, 2002; Carlile, 2004). Bridging operations are more situated in practice than the concept of *brokering*, which deals with the explicit transfer of an element of practice from one community of practice to another.

Brokering Activities

Brokering implies an active facilitation of externalized knowledge transfer across community boundaries. This is achieved through the translation, coordination and alignment of perspectives (Wenger, 1998). Brokering may be seen as part of a trajectory of change that furthers the alignment of interests between political actors or groups (Latour, 1987). While bridging operations involve tacit knowledge, created and shared through mutual interpretations of one's own acts and the acts of others (Weick, 1995), brokering involves the translation or transformation of explicit knowledge about how to do something from one community of practice to another. By convincing someone that you have a better system definition than another stakeholder, you align their interests with your own to have your system definition adopted by the wider organization (Latour, 1987; Levina and Vaast, 2005; Pawlowski et al., 2000). Thus, in any analysis of boundary-spanning knowledge-exchange, we need to ask in whose interest the translation of knowledge takes place and how it is mediated.

THE MEDIATING ROLE OF NEGOTIATION OBJECTS

It was argued above that boundary-spanning interaction is mediated through the interpretive negotiation of boundary objects such as business-flowcharts, that are plastic enough to be interpreted in different ways by various groups but convey sufficient common meaning for knowledge-coordination across boundaries (Carlile, 2002; Star, 1989). Star (1989) identifies four types of boundary object:

Repositories: ordered sets of objects, for example a library, that are used to deal with differences in the unit of analysis used by different groups. When using a library, one person may be interested in books in a certain category, another in books by a single author. Each uses different subsets of a joint categorization scheme.

Ideal-type Object: a deliberately vague object such as a high-level process-flow model. This provides a globally-meaningful abstraction that represents a meta-level framework for interaction, rather than being specific to any one domain of activity. This allows various groups to place their own interpretation on coordinating artifacts.

Maps (Terrain with Coincident Boundaries): objects that define delineated boundaries of responsibility or impact, such as a map that defines county boundaries but allows people to populate the county with different contents according to need. These objects allow different groups to pursue different goals while operating within the same scope, or to partition coordinated work.

Forms and Procedures: standardized objects, such as paper forms, checklists, or agreed language terms, that are devised as methods of common communication across dispersed work groups. These remove uncertainties, but constrain innovation and adaptation as they become "immutable mobiles" (Latour, 1987) – elements that are intended to change, but are not amenable to change because of the normative meanings that they acquire.

Star (1989) does not claim that this list is exhaustive – we may also add organizational information systems (Levina and Vaast, 2005) to the set of identified boundary objects. In addition, a limitation of the boundary object concept is that it focuses on the *informational* role of the artifact, interpreting boundary-spanning in terms of sensemaking across domains (what Star and Griesemer, 1989 refer to as an "information ecology"). This focus obscures other types of mediating object that permit bridging and brokering operations to succeed through the translation of roles and the basis of influence. All of these are relevant forms of interpretive translation.

For example, Hutchins and Klausen identify a set of interlocking work-roles and cognitive artifacts that enable a complex system of domain-specific work to be partitioned and coordinated across members of an airline cockpit crew who are trained in different domains. The movement of information through the system forms actors' expectations and mental models of the situation that enable them to coordinate their work when these expectations and models are shared. But coordination also depends on a processual review – a continual assessment of their own state of knowledge and that of others – that depends upon interlocking and well-defined work roles and the use of collaborative objects such as to-do lists, that capture the current state of complex, interdependent work processes (Hutchins and Klausen, 1998). In a large-scale study of virtual coordination in a global organization, Gasson and Elrod identified a social-network bridging object that permitted knowledge to be located and accessed through schematizing who-knows-what and leveraging interpersonal relationships between managers (Gasson and Elrod, 2006). Levina and Vaast (2005) identify IT systems as boundary-objects-in-use, emphasizing that their

boundary-spanning capability is emergent and relies on human boundary-spanners who leverage their interorganizational role to define the boundary-spanning role of the IT system. This requires the emergence of a new joint field of organizational knowledge that is recognized and supported by individuals occupying organizational roles that permit them to determine which boundaries should be spanned, whether agents into formal or informal boundary-spanning roles, who is chosen to fill a boundary-spanner role, and whether to encourage or restrict practices that employ IT systems for boundary-spanning (Levina and Vaast, 2005).

In the study of distributed interaction across work-groups, we can analyze the use of *negotiation objects* to understand knowledge coordination mechanisms across functional and group boundaries – and to determine how organizational knowledge is defined and adapted at the boundary. Table 2 summarizes various mediating roles of negotiation objects in the lS literature.

Table 2: The Mediating Roles of Negotiation Objects

Negotiation Object	Mediating Role	Examples
Stories and metaphors	Communicate and reinforce shared values and goals (know-why).	Managing organizational culture (Pettigrew, 1990); Framing focus of systems development (Davidson, 2002).
Shared frameworks for action	Transfer situated knowledge (know-how, and know-why) from one context to another.	Generation of polycontextual frameworks for action across organizational boundaries (Engeström et al., 1995); The production of conscription devices to enlist group participation around a set of interlocking roles (Henderson, 1999).
Organizational roles and interlocking routines	Mediate heedful interrelating (coordination of all four forms of knowledge) between human components of a "collective mind."	Coordinating distributed work on an airline flight deck (Hutchins and Klausen, 1998); Coordinating takeoffs and landings on an aircraft carrier (Weick and Roberts, 1993).
Social networks	Interpersonal relationships are leveraged across a workgroup to gain access to influential domain experts or managers who will represent interest of group to other organizational groups.	Operation of actor-networks in generating new scientific paradigms (Latour, 1987); Discovering project requirements in a distributed, virtual organization (Gasson and Elrod, 2006).
Affiliative objects	Coordination of group work over time is managed through "object-centered sociality," where affiliation to an artifact coordinates activity between individuals who share an interests in the object.	Coordination of scientists in HEP experiments achieved by means of a shared interest in developing specific technology objects (Knorr Cetina, 1999); Transformation of photocopier into a scientific object to mobilize multiple interests in copier research (Suchman, 2005).
IT system as emergent boundary object	Emergence of a new joint field of organizational knowledge that is recognized and supported by powerful individuals who determine which boundaries should be spanned and whether to encourage or restrict practices that employ IT systems for boundary-spanning	IT professionals acting as knowledge brokers between organizational communities of practice (Pawlowski and Robey, 2004); Organizational boundary-spanners employing IT systems as boundary-objects-in-use (Levina and Vaast, 2005).

THE ROLE OF NEGOTIATION OBJECTS IN BOUNDARY-SPANNING COLLABORATION

The exploratory study reported in this paper examines the mediation activities that enable boundary-spanning knowledge-sharing and innovation and the role of negotiation objects in these interactions. An analysis of the literature summarized above reveals a need to derive a new theoretical perspective to explain and support knowledge-sharing between people from different work-domains. In particular, the situatedness of knowledge in localized practice and the difficulty of negotiating work-practices across multiple knowledge-domains, raise the need to investigate he management of meaning at the boundary between communities of practice. The literature review above and an initial analysis of the data indicated three research questions, that are addressed below:

1. How do boundary-spanning groups engaged in e-collaboration negotiate meanings to provide *intersections of understanding*, using boundary objects?
2. How do boundary-spanning groups engaged in e-collaboration mutually construct and adapt a shared set of socio-cultural values and beliefs to provide a common framework for bridging operations?
3. How do boundary-spanning groups engaged in e-collaboration negotiate and manage the exercise of power and influence and what role do negotiation objects play in this process?

In the conceptual background discussed above, we explored a variety of negotiation objects that mediate the management of meaning across organizational groups. Meanings play a different role in each of the three types of boundary-spanning operation identified above. Distributed sensemaking involves multiple forms knowledge exchange, that employ boundary-objects to frame different aspects of the shared context of work (Carlile, 2002). Bridging operations involve the negotiation of shared practices that are derived through the use of collaborative cognitive artifacts and roles to provide a joint framework for action – such artifacts provide the basis for organizational improvisation in emergent knowledge processes (Markus et al., 2002; Weick, 1995, 1998). Brokering operations appear to involve more explicit exercises of power and influence, that are negotiated across organizational group boundaries (Levina and Vaast, 2005; Pawlowski et al., 2000). The following study examines the evolution of five collaboration systems, to explore the role of negotiation objects in establishing a boundary-spanning collaborative system of work.

RESEARCH SITE AND METHOD

The change initiatives took place within a large US manufacturing company, which will be given the pseudonym ContainerCo. This company is a multinational manufacturer and distributor of various types of food, cosmetic and pharmaceutical containers. The company has manufacturing and distribution plants in many states across the USA and is a market leader in its field. Its supplies a variety of multinational companies which are market-leaders in the food industry and a large number of smaller customers. The company's use of information technology has been limited. While they have updated their production technology, to maintain a leading-edge in this area, information technology has not been considered a priority in their highly cost-sensitive environment. The company faces many competitive pressures, not least the constant loss of its staff to competitors. Because of this, the company is highly sensitive about disclosing detailed information to line managers and workers that its competitors might find useful. This research study was therefore able to focus on system adaptation in context, as most of the

systems in use have been adapted from existing components, rather than formed by the expectations of IT product vendors.

ContainerCo had assimilated many smaller companies in the few years prior to this study, each of which operated as a separate division. Because of the diversity of cultures and manufacturing constraints, each division was primarily judged by how well it controlled its operating costs. Managers found it difficult to introduce other indicators that relate to effectiveness rather than efficiency, because of the corporate management's cost-focus. The company had a conservative management culture, within which silo-ism and complacency flourish. Yet ContainerCo faced increasing global competition, in a product-market that was challenged by customer demands for innovative products, adoption of a rapidly-developing set of technical developments (for example, new internal-coatings or chemical additives to provide the container's contents with a longer shelf-life), and cyclical consumer demand. This was the background of multiple attempts by upper and middle management, to invent new ways of working that were mediated by computer-based information systems.

The exploratory research study reported here examined various forms of computer-mediated collaboration across the organization and how these were supported by information and collaboration IT systems. Knowledge-sharing processes of those managers involved in major IS-related change initiatives were studied, over a period of nine months, to understand how different forms of shared knowledge were constructed. This process involved interviews with key managers involved in various change initiatives as well as non-participant observation in site visits, process improvement meetings and IT systems requirements elicitation. Organizational managers were interviewed at a variety of levels: senior management, middle management and project managers (project, in this context, relates to a collaborative work project, rather than an IS development project). Informant and participant characteristics are summarized in Table 3.

Table 3 : Informant and Participant Characteristics

No.	Organizational Role	No.	Job Title
3	Strategic management, Corporate Division	1	CFO of Corporate Division A
1	Strategic management, International Operations	1	Director of Quality, Corporate Division B
3	VP, Corporate Operations	1	VP of Sales, Corporate Division B
3	Senior Middle Management (occasional participants)	1	Director of Operations, Corporate Division C
1	IT Systems Development	1	Director, South American Operations
4	Production Plant Managers	1	VP, Corporate Affairs and Public Relations
12	Ad hoc discussions with plant workers during site visits	1	VP, Environment, Health & Safety
		3	Operations/Production Manager
		1	IT Development Manager
		4	Production Plant Manager
		4	Production line supervisor,
		8	Production worker

To anonymize data, corporate divisions have been identified with alphabetic/generic labels instead of division names. Most of the participants were core participants in the organizational and IS change initiative, but some were occasional participants, who were called upon to supply

specific expertise. In addition, project documents and models were analyzed to understand the way in which the change process had been performed and the elements upon which it had focused. Different managers provided demonstrations of the various collaboration technology applications used in this company and the various organizational systems were observed in use.

A qualitative data analysis was performed one month into the study, to identify the main themes in the observed boundary-spanning systems definition and use and to provide a framework for ongoing interviews with a range of stakeholders in the design and evolution of the various information systems discussed here. The three research questions defined above were formulated at this point, to guide the next stage of the investigation. As the initial thematic analysis indicated a strong focus on the ways in which boundary-spanning negotiation and technology mediation were used to overcome cultural and organizational barriers to knowledge-sharing, the follow-on data collection and analysis was focused on the mechanisms activities that enabled boundary-spanning knowledge-sharing and innovation.

We conducted interviews using techniques based on Soft Systems Methodology (SSM) (Checkland, 1981; Checkland and Holwell, 1998). SSM emphasizes the separation of real-world thinking (current state) from ideal-world thinking (desired change). Soft systems thinking recognizes that individuals will have multiple and often conflated understandings of what they are trying to achieve and why. The SSM approach to investigating a problem-situation provides ways of separating out these conflated elements and identifying the multiple goals and purposes of a desired or actual organizational change. An SSM conceptual model provides insights into the ways in which participants understand what change processes and mechanisms are required, or have taken place, for debate and comparison with their "ideal world" state. This approach permits issues to be surfaced that relate to a tacit knowledge of distributed activities, permitting the researcher to explore the multiple purposes of and rationale underlying the stakeholder's post hoc rationalization of change goals.

A qualitative analysis of interview data, ethnographic observations, and SSM model elements was performed to explore the issues raised by each of the three research questions given above. Research findings were validated in follow-up interviews, emails and phone interviews with both corporate and plant managers and production workers once the data collection phase of this study had finished and data analysis was complete. We revised one of the system cases below, to add more recent developments and conducted additional interviews to gain multiple perspectives on these developments.

FINDINGS

The findings from this study are presented in the form of short case analyses of an inter-group virtual collaboration system, describing the evolution of the main collaboration systems that supported knowledge-sharing across organizational boundaries.

Collaboration System 1: Knowledge-Sharing For Improved Production Management Effectiveness

This system was set up at the instigation of the senior manager responsible for operations in the US food and beverage container production plants. On a visit to one of the local plants, he was struck by how many good ideas the production workers had, to save costs and to improve the quality of the finished product. So he wanted to set up a “knowledge-base”, to allow workers to share their ideas. However, there was a cultural barrier to this concept. Production workers were treated as “theory X” employees (MacGregor, 1960). They were assumed to have an inherent

dislike of work and to require coercion or monetary rewards to get them to exert effort toward organizational objectives. There was a real danger of such workers leaving to work for rival firms, therefore any information systems that they used must provide them with little information that was of use to competitors, even at the plant-manager level. The new system was therefore designed with two objectives in mind: to provide an explicit reward for production workers to share knowledge and to prevent them abusing access to the Internet system that was to be used to share this knowledge (the lowest cost option). The solution was to constrain collaboration by permitting them to share knowledge by proxy only. They would submit ideas to their plant manager and would receive a monetary reward for any idea that the plant manager thought worth pursuing, as well as being identified on the company intranet website as the originator of the idea. This increased their local status, but it had the constraint that the knowledge shared was limited to knowledge that the plant manager consider valuable, rather than knowledge that was valued by plant workers.

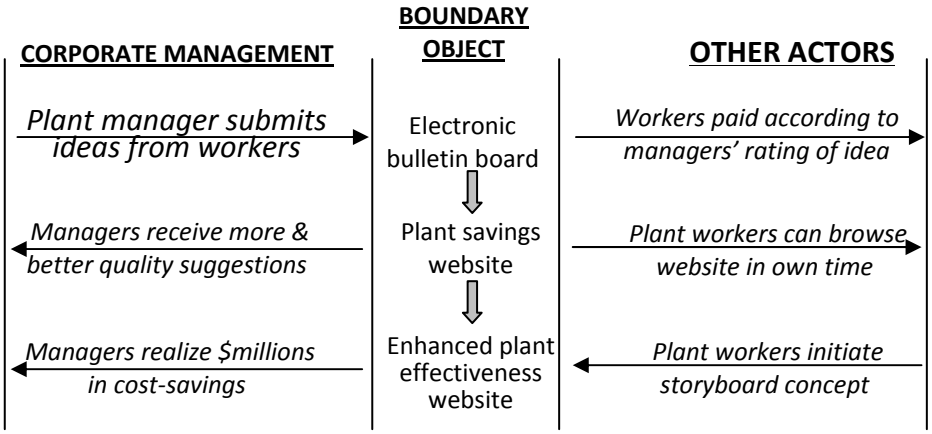

Figure 1: Evolution of production management system

The adaptation of this system illustrates how manual workers, although constrained by a cultural attitudes from collaborating directly, were able to improvise ways of collaborating indirectly. The example also refuted the Theory X worker thesis, showing them to be "theory Y" employees, who were motivated by intrinsic rewards and capable of self-directed engagement with work improvement goals (MacGregor, 1960). The manager responsible for the production management system constantly referred to how innovative the plant workers had proved to be and how excited they were, not by the idea of financial rewards, but by the idea that other plants could use the innovative procedures that they had developed. The workers themselves were enthusiastic, describing how proud they were to have saved the company so much money and accessing the plant improvement system in their own time to browse ideas and adapt or improve these to apply to their own local production domain. In fact, the system was so successful that it constituted an informal social network, spanning the diverse production areas of this large and complex organization. For example, one worker saw a photo-essay by a worker in a different type of plant, where lubricating oil containers had been tipped using wedges to access the last inch of oil (a cumulatively massive cost-saving). He adapted the idea to the lubricating reservoirs on his own production line, to provide a gravity feed which would prevent the reservoirs from running dry (a very expensive occurrence, as the production gears seize irrevocably). The worker spent weeks developing the idea and appeared genuinely unconcerned whether he won an award; he was much more concerned with preventing serious stoppages to the production line.

Collaboration System 2: Safety and accident prevention

This system was introduced by the middle manager responsible for plant safety training, as he felt that plant managers needed to be more aware of safety risks, in order to reduce the company's potential legal liability. He instituted a safety and accident report Listserv system. Plant managers were automatically registered for the Listserv and received daily reports of all serious accidents and safety breaches at US plants.

However, he found that the system appeared to have little impact. So he set up an email dialog between plant managers to discover why. It appeared that all the reports were perceived as undifferentiated and plant managers could not tell which should be responded to. So the plant managers delegated a number of their key employees to set up a safety inspection team. This team of "specialists" has time allocated for them to review all of the plant accident and safety reports and they summarize these for managers, allocating criticality ratings to each incident. Plant managers are required to respond to highly critical incidents, with a short report, describing what action they have taken to avoid this type of incident at their own plant. These are followed up by the local specialists, who advise managers of additional actions that are required and ensure that these are completed.

The adaptation of the system involved a wide range of stakeholders (members of the safety inspection team, who are normally line foremen or senior plant workers). Through the plant managers and a short-lived safety action project team, they were able to identify people with relevant expertise in safety issues throughout the company. Contact details for identified experts are provided as part of the incident summaries and plant managers can contact safety experts directly, to determine the sort of action that they should take. The safety manager now reviews the outcomes of these actions and contacts plant managers if he feels that further action is required.

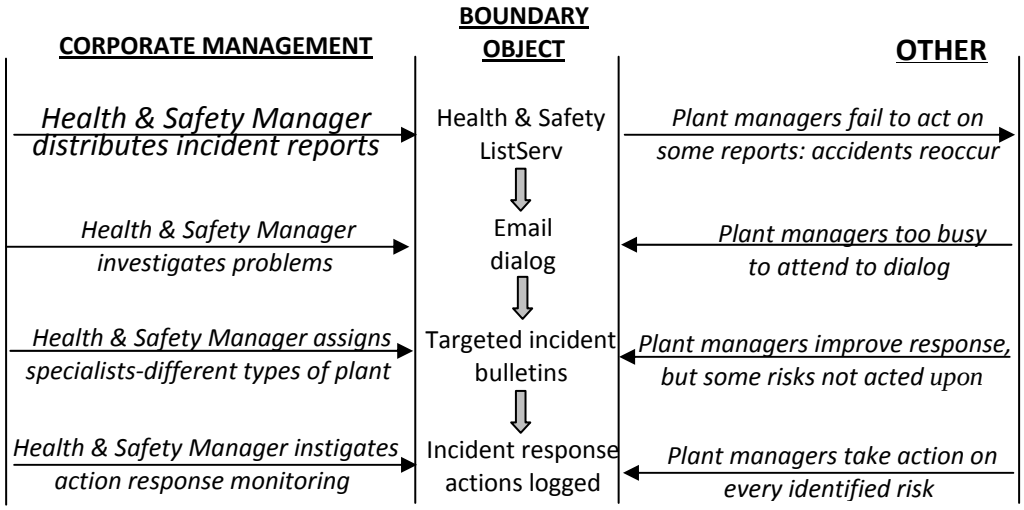

Figure 2: Evolution of safety and accident prevention system

This system adaptation demonstrates the difficulties in identifying similarities between different contexts and situations. The collaboration here took place largely by email: the most sophisticated technology involved was an Email Listserv application. Yet the system has been adapted, because of the ability of key collaborators to identify their common problems and to agree a mutually satisfying way of alleviating these. The legal liability issue expedited this: as

the plant managers are legally liable for negligence within their plant, there was a great incentive to find a collaborative solution to their problem.

Collaboration System 3: Financial estimation and forecasting

The system in question here is a case of mutual adaptation, in a way that is uniquely ad hoc and decentralized. The company has a single accounting system, that provides centralized reporting of financial summaries and key indicators to senior managers. Financial reports are provided monthly and the system is unable to provide detailed breakdowns of figures by any parameters than those used in the formal company reports. This "monolithic" system was considered unsatisfactory by all but the company's Board of Directors.

But the IS Manager remained unresponsive to requests for more detailed breakdowns, because of the cultural and ideological values espoused by the company. Cost constraints dominate over other considerations, so the IS Manager was able to successfully argue that he could not provide the functions requested without recruiting additional development staff (which would have been unacceptable). The competitive situation, with the company's competitors frequently poaching staff at all levels, added to the general degree of paranoia, which enabled the IS Manager to take no action because he could not guarantee the security of the data that he provided.

The situation was becoming intolerable for some middle managers. One manager commented that their cost estimation process was flawed and that large customers appeared to have more accurate breakdowns of their internal cost structures than company managers had. He added that they frequently negotiated with middle managers, to the point where the manager felt that the order would be only marginally profitable and then dealt with senior managers, to procure a further discount. The middle managers were unable to remonstrate effectively, as they did not have the figures to support their hunch that they were losing money on the order, and senior managers continued to provide discounts to large customers, as they were afraid of losing their business. So the middle managers began to collude in establishing an informal financial information system. They collected local figures as these were entered into the accounting system and employed their own IT support staff, to develop a myriad of "unofficial" applications. Data from these applications was exchanged with other middle managers using an exchange, or barter system, where a manager would email another manager, to obtain data for a specific purpose and offer him some data that he required in return. This was a highly distributed system, but also highly ingenious. One manager commented:

> "The data is all there, it's not as if we're making stuff available that shouldn't be. But it's all on paper. Last time we needed to calculate the cost of doing something, to make a case to senior management, it took five of us [senior managers] two days each, to do it. This way, we have the data when we need it and each person makes sure their data is secure."

Over time, a further adaptation took place. As the managers now had access to business-unit financial information, they were able to define key performance indicators for each specific business unit and translate these to a form that disguised the financials and provided plant-specific performance targets for plant managers, such as target materials consumption per 100,000 units, or target production time for 100,000 units. This overcame a huge resistance issue on the part of senior management, who were vehemently opposed to specifying financial targets at the plant level because the job mobility of plant managers meant that competitors could easily obtain their internal cost-structure information. Local plant managers now reported according to these "disguised" targets and the corporate managers were – at last – able to have IT implement a

system for automated business unit performance monitoring and forecasting, on a plant by plant basis.

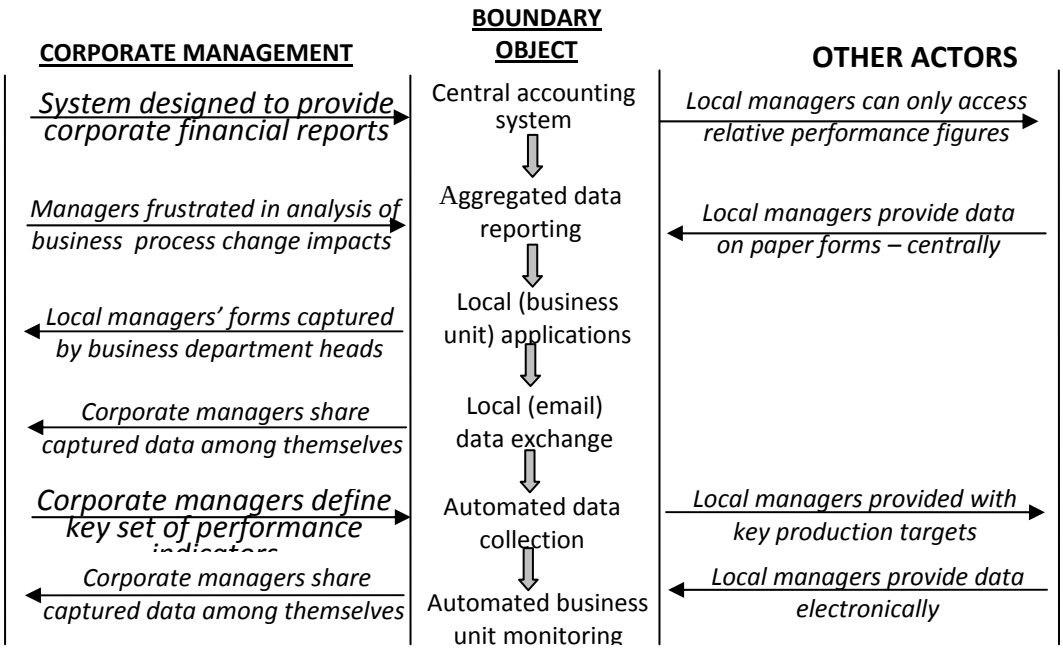

Figure 3: Evolution of financial estimation-forecasting system

This Collaboration provides an excellent example of a completely distributed collaborative data exchange, exploiting the informal, social network of corporate managers to develop ways of achieving a formal business unit monitoring mechanism. The system has adapted: IS as managers are asked for specific data, they start collecting this on a regular basis and this resource provides the basis for a data exchange between various groups. While the IS Manager controls the formal accounting system, multiple middle managers collaborate to provide an informal system of local applications that really account for company operations.

Collaboration System 4: Process quality improvement

The purpose of this system is to support the company's "quality roadmap". Senior managers, led by the Chair of the Board for US Operations, had determined to instigate a continual improvement initiative, based on a set of key performance indicators. However, in the case of plant management, there were some critical cultural problems. Employee turnover among plant managers was high: the average period of tenure was only three years, before a plant manager left to work for a competitor. No quality improvement system could provide plant managers with the detailed cost breakdowns that they required to run the plant, because the data would be advantageous to competitors. Cost minimization was the prime decision criteria for most resourcing decisions, and often the only criterion at plant-level. Yet plant managers were not allowed access to detailed cost figures.

The solution was to provide plant managers with relative cost figures, based on historical data. These indicators told a plant manager, for example, that the price of rolled steel had risen by 1% from the price paid by that plant for the previous month, that the average hourly cost of employing a worker to set up an assembly line at that specific plant was 0.2% higher than last month and that his monthly target was to reduce plant costs by 0.15%. But the manager did not

have access to the actual costs and targets were set according to a complex model that accounted for cyclical variances and prior plant performance. As one manager termed it, this was a heaven-sent opportunity to "play the game". Plant managers colluded in passing on tips on how to fool the system, by reducing costs in one area, that was closely monitored, then ascribing costs to other areas. This bridged the local knowledge of how to run plant-specific operations with the global knowledge of how plant management incentives were structured. It was well known, by the central financial managers, that some plants were many times more efficient than others. Yet the targets were set relative to a specific plant's historical performance, so an inefficient plant had no incentive to become efficient.

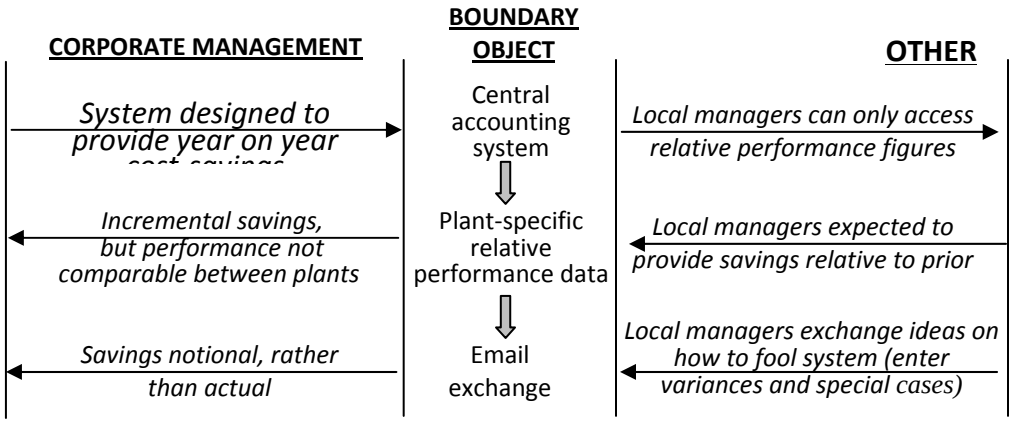

Figure 4: Evolution of process quality improvement system

This system provides a prima facie example of the problems when local knowledge is privileged over global knowledge. As there was no sharing or comparison between plants, it was not possible for any effective collaboration to take place between plant managers. The only e-collaboration that did take place was of a kind that acted against the interests of the company, in permitting plant managers to share ways to fool the system.

Collaboration System 5: Business process innovation

This system was sponsored by a senior middle manager, who reported to the US Corporate Operations Board. He had been involved in a previous business process improvement initiative and, although that initiative had failed, felt that the improved understanding that they had obtained could form the basis for substantial change. The previous BPI initiative had identifies several bottlenecks in company performance, which he felt could be improved by the provision of improved information systems and closer coupling through e-collaboration systems. He had assembled several project teams, with the permission of the board and these teams were actively employing elements of the four systems discussed above, to obtain data with which to make a case for improvement, and to collaborate among themselves. Project team members were dispersed among various company offices and groups. They had been selected on the basis of their expertise in various areas of operations and their ability to influence other managers to embrace change. The system that they had set up to collaborate consisted of two elements. Initially, they established a central database, from which repositories of information, financial and operating indicators was used as a shared resource by the group. Access to this was provided via a secure intranet connection and it remains in use, providing a significant source of historical management information. The second evolved through need: one of the change teams located a low-cost, shared collaboration application, using intranet technology, with a "design space"

window, a shared discussion group and a "to do" list of individual and shared actions. The group leveraged this technology by accessing the distributed IT resources implemented by local managers. One project group member worked for a manager who had a decision support system – access to this was used by the group to produce "what if" models of alternative courses of action. Another project group member was able to provide access to a local IT developer, who acted as a model facilitator for the group, producing information-flow models and high-level database designs for their proposed procurement system.

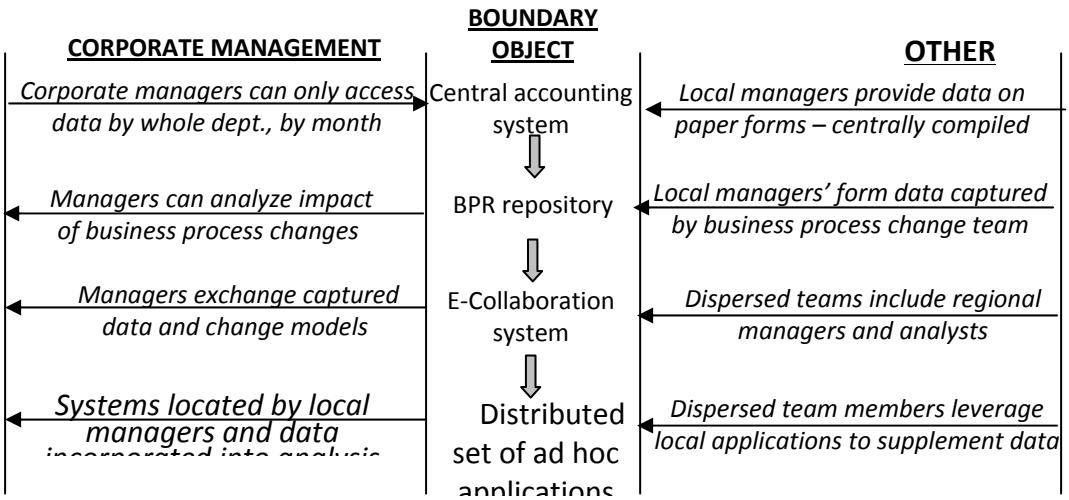

Figure 5: Evolution of business process innovation system

The group were therefore able to obtain access to a great many IT-mediated collaboration resources, not in spite of, but because of their distributed locations. Cost constraints were managed by obtaining access to existing applications that had been purchased for other uses and their cross-domain expertise allowed them to supplement each others' ideas on how to use IT systems to solve operational problems. Despite its effectiveness, the main problem faced by this team was the existence of a rival process "roadmap" for the continual improvement quality initiative. As this was associated so closely with the person who was now the Chair of the Board for US Operations, a close association with the quality initiative was seen as political support for this individual. The business process improvement initiative was viewed as little different from the continual improvement quality roadmap: managers talked of the "two rival roadmaps" as if they were different routes to the same end. So the business process initiative, while highly successful in using e-collaboration to produce potential systems of change, was in danger of failing because of the meanings ascribed to their process by managers who saw the difference as one of political affiliation, rather than the scope of change.

DISCUSSION

Table 3 summarizes the different types of boundary-spanning activity observed in the Collaborations reported above. The types of knowledge exchanged were related to the three categories of boundary-spanning collaboration identified in the conceptual background above: collaborative sensemaking, bridging, and brokering.

Table 4: Boundary-spanning negotiation forms of each Collaboration

Collaboration System	Type of Knowledge Exchanged	Design Intent of Boundary Object	Bridging Operations	Brokering Activity
1. Production Management Improvement	*Process knowledge* related to specific local circumstances and global needs.	*Initially:* Forms and procedures, to control management interactions with "theory X" workers. *Now:* Repository, to provide a social network resource around which "theory Y" workers can develop innovative production technology applications.	Demonstrating idea as storyboard provides a coherent narrative to manage meaning across knowledge domains.	Convincing plant manager of importance: meaning is managed to align managers' interests with those of workers
2. Safety & Accident Prevention	*Process knowledge* related to explicit translation of global circumstances to local needs.	*Initially:* Terrain with coincident boundaries – different elements are extracted from incident reports for different work contexts. *Now:* Forms and procedures ensures conformance to regulatory requirement	Presentation of incident report to a specialist who is familiar with context of work permits bridging between global safety issues and local plant applications of lessons learned.	Determination of action required, by specialists translates local knowledge to produce global framework for action; Tracking what actions are taken attaches global meaning to local actions.
3. Financial estimation & forecasting	*Social network knowledge* related to location of expertise and knowledge about basis for corporate profit calculations	*Initially:* Forms and procedures intended to preclude variations on formalized procedures *Intermediate:* Terrain with coincident boundaries: middle managers share information on various transactions to allow them to analyze financial information for autonomous planning Now: Access to information allows managers to collaborate across social network to model financial drivers of various types of business unit and define key indicators for automatic monitoring application	Informal communications leverage the social network to provide access to specific information and expertise that was blocked by formal management structures	Managers do each other favors: they exchange power over local sources of information for wider information access.
4. Process quality improvement	*Process knowledge* and *contextual framework for action* enable identification of global commonalities between local events.	Ideal-type object – data is provided at an abstract level to coordinate activity across managers of diverse plant operations without specific financial details needing to be divulged. Form of object selected to prevent industrial espionage	Gaps between local operational knowledge & global understanding of mgt. incentives is bridged by informal network of managers, mediated by IT system.	Informal social network is leveraged to aligns interests around sharing knowledge. Managers exchange ways to fool the system, trading sources of power in *quid pro quo.*
5. Business process innovation	*Contextual framework for action* abstracts local knowledge for global application.	(i) Repository (ii) Terrain with coincident boundaries – the structure can mold to any purpose; (iii) Distributed repositories.	BPR teams leverage technology by accessing distributed IT resources of local managers; these provide the basis for common perspectives and global changes.	Group work together to produce process models of desired change. (Leveraging manager's social network).

LEVERAGING INTERSECTIONS OF UNDERSTANDING

Research question 1 asked how do boundary-spanning groups engaged in e-collaboration negotiate meanings to provide *intersections of understanding*, using boundary objects?

In case 1, the process management cost-saving ideas system, the system adaptation occurred because the workers suggested innovative ways of bridging the knowledge-gap between different communities of practice. After gaining access to the system, they realized that the information provided did not communicate the deep insights needed to bridge the different cultures and knowledge pertaining to different production plants. So they suggested a photographic storyboard presentation concept, to act as a bridging operation. The explicit alignment of interests (worker interest in being rewarded for their cost-saving idea and plant manager interest in being seen as a progressive manager) were aligned by convincing local plant managers of the value of these photo-essays, by demonstration. Once the concept had been adopted, the alignment of interests (i.e. support by local plant managers) became self-sustaining because of the high profile associated with each set of cost-savings.

In the second case, the interests of different communities - corporate management, who had an interest in reducing legal exposure because of accidents, and plant managers, who had an interest in avoiding sanctions by corporate management – were more explicitly aligned. The emphasis lay more with the brokering activity (determination of required action and tracking action taken). The bridging activity however, was still important, as some "translation" and targeting of the incident reports was required, before plant managers could understand how these reports related to their plant. This process employed a team of specialists, each of whose personal expertise bridged the two communities to be spanned.

In case 3, there was a much more active and explicit recognition of the nature of the knowledge that needed to be transferred between communities. A manager in one business area would identify information that they needed from another business area and ask that manager to collect and compile it for them. In exchange, they would collect information for that manager. So the bridging operations consisted of a series of realizations about *who-knows-what* (or who has access to what), that became more systematic as managers became more practiced at recognizing sources of information. These were not facilitated by electronic systems, but resulted from face-to-face encounters (or telephone discussions between managers who knew each other).

In case 4, system evolution was constrained by cultural values, that prevented adaptation. The insistence that managers could not use the system for any ends other than local, comparative cost-management, meant that the only interactions available to managers concerned how to fool the system by entering cyclical or product variances that would make it appear as if substantial cost-savings had been achieved when they had not.

In case 5, again, an active and explicit recognition of the types of knowledge required led to an active system of information brokering between managers in different areas of the business. As for case 3, this meant that the bridging operations consisted of a series of realizations about *who-knows-what* (or who has access to what), which were largely facilitated by face-to-face meetings, or the suggestions of others in the manager's social network.

CONSTRUCTING SHARED VALUES AND BELIEFS

Research question 2 asked how do boundary-spanning groups engaged in e-collaboration mutually construct and adapt a shared set of socio-cultural values and beliefs to provide a common framework for bridging operations? To answer this question, we examine the rationale

underlying the emergent nature of the IT system used for collaboration. In the first three cases, the initial IT system was designed to achieve a purpose different than the one it now fulfils. The current purpose was arrived at through a process of adaptation, in which distributed groups of organizational actors re-created the system, to achieve locally-defined objectives.

The last two cases represent systems that were did not adapt. In the case of the quality improvement system, this was because of cultural barriers to change. Senior management did not wish local workers to be able to access detailed cost and operating information. So the system was designed as an "immutable mobile" (Latour, 1987), which impedes adaptation. In the case of the financial estimation and business process change systems, the immutability of the formal system (the corporate accounting system) was overcome by bypassing it. A set of informal and semi-formal systems were implemented, that depended part on e-collaboration, but also on personal collaboration across a social network of contacts. These cases emphasize the importance of informal systems (Land, 1992), in supporting cases where required knowledge can be identified explicitly and so brokering activities become more significant than bridging operations.

In cases (1) and (2), it is noticeable that the original intention of the system was subverted during system evolution and adaptation. Originally, the production management system was designed to support Theory X workers (MacGregor, 1960), who could not be trusted to participate, except through the filtering effect of their managers. But is was through Theory Y behavior (MacGregor, 1960), that these workers demonstrated the potential of the system. By actively seeking opportunities to access the system *in their own time*, they initiated changes that provided support for worker autonomy and that proved the value of their active contributions to the system. In each of these cases, system adaptation resulted in a form of e-collaboration that took the opposite nature to that planned.

NEGOTIATING AND MANAGING MEANINGS

Research question 3 asked how do boundary-spanning groups engaged in e-collaboration negotiate and manage the exercise of power and influence and what role do negotiation objects play in this process? To answer this question, we examine the role of expertise and the ways in which this was identified, exchanged and "bridged" to provide sources of organizational power.

The findings and analysis demonstrate that the exchange of factual knowledge was only one of a number of interactive exchanges supported by the electronic collaboration systems. Other interactions emphasized expertise (both explicit and bridged by some means of translation) and the processual and contextual framework underlying organizational decision-making by senior management. We can see that the expertise relevant to specific local practices needed to be translated by adapting or abstracting the local framework for action to be meaningful in the context of global practices, forming framework for boundary-spanning expertise. In all the cases discussed above, there was a strongly-perceived need for boundary-spanning mediation activities, to overcome the structural barrier of silo-ism and the cultural barriers of management complacency and secrecy. These barriers constrained boundary-spanning collaboration and prevented the derivation of a common language through which knowledge could be exchanged at a global (or community-spanning) level. In each case, the coordinating IT system, or the social network that was mediated by this system provided the basis for circumventing these barriers.

Knorr-Cetina discusses how temporal, object-centered coordination is substituted for social authority in group work. The coordinating power of a workgroup is based on their "proximity" to

a coordination object, the unfolding (emergence) of which provides direction and structure for the group process (Knorr Cetina, 1999). In cases 3, 4 and 5, we saw how social networks between managers were mobilized using coordinating system-objects to actively broker boundary-spanning forms of knowledge. However, in case 4 the cultural barriers and different value-systems of corporate and local management led to a counterproductive mobilization of the social network and the coordination failed.

In cases 1 and 2, the centrality of know-how was significant to collaboration across knowledge domains. An implicit recognition of this on the part of those involved in systems adaptation led to the derivation of a "common language" between the various communities of practice. Both the evolution of a photographic scenario of change and its implications, and the evolution of a way of assessing whether plants managers had understood and acted upon incident reports, could be said to have been facilitated by the ways in which the IT systems lent themselves to experimentation. This process essayed different forms of knowledge brokering, until a representational form was discovered that achieved the desired results.

ROLE OF NEGOTIATION OBJECTS IN MANAGING MEANING ACROSS E-COLLABORATION SYSTEMS

Collaborative objects have social power, in defining the interpersonal or intergroup relations that constitute an organization. Knowledge objects have epistemic power, in defining the meaning and legitimacy of various forms of knowledge (Henderson, 1999; Knorr Cetina, 1997). We may be moving to a period of object-centered management, where the temporal coordination of an evolving collective artifact is substituted for social authority in group collaboration. The influence of a boundary-spanning group on collaborative processes is coordinated by their "proximity" to this form of bridging object, the unfolding of which provides direction and coordination for the group process. Social relations are mediated by knowledge objects, that unfold and evolve through collaboration around the object. Thus the meaning of work – and of the social relations supported by the object mediated collaboration – is not a static construct (Knorr Cetina, 1999). Definitions of "valid" and "relevant" knowledge become subject to negotiation and joint improvisation, constraining how technology-supported systems of interaction are defined (Latour, 1991). This is reflected not only in collaborative work-practices, but in the resources that mediate boundary-spanning interactions. Local knowledge is amenable to transfer across organizational boundaries only when this process is mediated by knowledge-translation mechanisms that take into account the contextual and socially-situated nature of the knowledge exchanged (Carlile, 2004; Henderson, 1999; Knorr Cetina, 1999). We have seen, through the findings of this study, that it is not only the mediating power of the negotiation objects themselves, but their organizing power in assembling social networks, that permits the management of meaning across polycontextual boundary-spanning collaborations.

The role of negotiation objects is most explicit in the management of meaning for sensemaking. Various form of object provided the basis for a common framework for action across functional workgroups and business units, supporting the emergence of a shared perception of common interests, that enabled further improvisations around less concrete mediation mechanisms. But meaning was also managed through the provision of a bridging mechanism, that coordinated social relationships and mediated narratives of communication between users of the various collaboration systems. This permitted sources of expertise to be located and informal networks of knowledge-sharing to be established, some of which extended the original goals of the collaboration system and some of which subverted these goals to support the common interests of local managers across workgroups. The most striking effect of these

collaboration systems was to enable a brokering of influence that undermined the formal structural and cultural barriers which constrained meaningful collaboration between workgroups. Ironically, the brokering of influence and power mediated by these systems produced much more meaningful forms of collaboration than their originators intended, simply by providing the means to circumvent the silo-ism that dominated the company.

CONCLUSIONS

This paper examines the ways in which negotiation objects – objects used for boundary-spanning, bridging, or brokering purposes – mediate collaboration across distributed workgroups in large organizations. Objects are increasingly displacing direct social relations in the mediation of distributed work. When collaboration between organizational groups is virtually-mediated, the "management of meaning" that used to be centralized in strategic managers is distributed. In collaborating around virtually-mediated knowledge objects, various groups compete to define the meanings attached to those objects, in order to define the importance and legitimacy of various forms of organizational knowledge and thus control organizational roles, structures, and processes. This study analyzes how representational, technical, and organizational resources provided mediation of knowledge between different work-groups and how different forms of negotiated mediation led to the adaptation of the information systems that they defined and use in common. It examines the mediating role played by various forms of "negotiation object," to reach a new understanding of how we may design e-collaboration systems.

The findings reveal the multiple purposes of “shared” knowledge in collaborative group activities and the role of system adaptation in enabling various forms of boundary-spanning e-collaboration. In each case, the formal system that acted as a boundary object privileged explicit, articulated knowledge over knowledge that was embedded in local artifacts or practice. If we are to provide collaborative initiatives with ways of making embedded knowledge articulable, we need to focus on supporting informal communications as a supplement to formal system communication paths. This is the basis of flexible system design, that is amenable to adaptation. We also need to recognize the significance of social (as distinct from technical) networks, in facilitating boundary-spanning collaboration. We need ways of assessing whether corporate value-systems impede collaboration and whether these impediments offer more value to the company that removing them. Often such systems do impede collaboration, simply because they focus on organizational control at the expense of adaptation. To quote Weick:

> “Control drives out innovation, organization becomes synonymous with control and generic subjectivity becomes sealed off from any chance for reframing, learning and comprehension of that which seems incomprehensible.” (Weick, 1995, page 73)

The contribution of this paper is to explain the various types of coordination mechanisms in boundary-spanning design and to suggest how the post-delivery redesign activities that are referred to as "adaptation" might be facilitated by various forms of negotiation objects. The summary provided in Table 3 has critical implications for theory and practice in the design and management of information systems for virtual organizations. Unlike much of the work on distributed cognition, this study demonstrates that group work does not result in a collective (cognitively-shared) artifact that embodies knowledge-frameworks at the boundary between group domains. Instead, distributed cognition appears to reside firmly in the social networks that underlie distributed, virtual organizations. Rather than the formal transactive memory systems advocated by distributed cognition theorists, it appears that informal transactive memory systems

are required for distributed adaptation. Group work that is distributed across place and time appears to result in negotiated objects that represent a distributed understanding of both the products and the processes of organizational effort. Attempt by various managers and IT design groups to impose a specific way of working on virtually-distributed managers and workers failed because of the ability of various groups to manipulate the interpretive flexibility of the distributed information system. Even when the system possessed little interpretive flexibility, as was the case with the process quality improvement system managers developed bridging mechanisms using informal social networks to pool their knowledge of how the incentive systems that underlay the formal boundary-object were structured. The resulting negotiation objects provide a distributed coordination power that is missing from the IT systems designed for more formal (and planned) systems of management.

Knowledge creation and sharing in organizations is most often assumed to involve direct interactions. It is true that the creation of shared knowledge is really only feasible when people share and improvise local practices, through membership of the same workgroup. However, innovation in virtual organizations involves a range of different stakeholder groups, spanning many different domains of professional practice. Definitions of "valid" and "relevant" knowledge become subject to negotiation and joint improvisation. This is reflected not only in discourse, but in the resources that mediate boundary-spanning interactions. This study analyzed how various technical, organizational, and social resources provided mediation of knowledge between different work-groups and how the use of various negotiation objects led to a joint adaptation of the information systems that these groups defined and used in common.

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