# BROKERING KNOWLEDGE: LINKING LEARNING AND INNOVATION

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## ABSTRACT

*This paper presents a model of innovation, knowledge brokering, that explains how some organizations are able to routinely innovate by recombining their past knowledge in new ways. While existing theories of organizational learning and innovation are useful, the links between them are crucial for understanding how existing knowledge becomes the raw materials from which individuals in organizations construct innovative solutions. This model develops these links by grounding processes of learning and innovation in the larger social context within which they occur. Using a microsociological perspective, this article draws together research spanning levels of analysis to explain innovation as the dissembling and reassembling of extant ideas, artifacts, and people. Previous research has suggested that firms spanning multiple domains may innovate by moving ideas from where they are known to where they are not, in the process creating new combinations of existing ideas. This paper more fully develops this process by linking the cognitive, social, and structural activities it comprises. Knowledge brokering involves exploiting the preconditions for innovation that reside within the larger social structure by bridging multiple domains, learning about the resources within those domains, linking that knowledge to new situations, and finally building new networks around the innovations that emerge from the process. This article also considers the origins of knowledge brokers as*

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*firms committed to this innovation strategy, the structural and cultural supports for the knowledge brokering process, and several obstacles to the process that these firms experience. Finally, I discuss the implications of this model for further research on innovation and learning, and the implications for other organizations seeking to establish their own capabilities for brokering knowledge.*

## INTRODUCTION

The central questions guiding the study of knowledge in organizations are, ultimately, why it is so difficult for organizations to learn from their experiences and why it is so difficult for them to forget these lessons when faced with a changed environment. Underlying these questions are the seemingly contradictory tasks of, on the one hand, acquiring and exploiting existing knowledge and, on the other, generating new knowledge. The organizational learning literature addresses how organizations learn, remember, and apply the lessons of their past (Levitt & March, 1988; Huber, 1991; Walsh & Ungson, 1991), focusing on the adoption of external knowledge and its diffusion within the firm. As Huber (1991, p. 89) states: "an organization learns if any of its units acquires knowledge that it recognizes as potentially useful to the organization." The innovation literature considers how organizations generate new knowledge (Wolfe, 1994), typically focusing on the invention, or internal generation, of new products or processes where none had existed before, what Kanter (1988, p. 170) describes as the "creation and exploitation of new ideas." While each perspective is useful and necessary, neither is sufficient for understanding how existing knowledge provides the raw materials for creating new knowledge. As a result, the organizational processes that link learning and innovation remain relatively unexplored (Fiol, 1996).

### *A Science of the Concrete*

This article constructs a model linking learning and innovation in organizations. Innovations tend to be defined globally, as in Schumpeter's (1934) "gales of creative destruction" that sweep away existing structures, and yet they are enacted locally. To capture how the local events of the innovation process are embedded within such a global context, I adopt a microsociological perspective (Fine, 1991). Microsociology is concerned with how individual cognition and action is shaped by, and in turn shapes, the social structures in which they take place (e.g. DiMaggio, 1997). Such a perspective is useful because, while more micro perspectives address issues of individual creativity and its local context and more macro perspectives address issues of organizational innovation and social structures, the interactions between these levels of analysis – which give meaning to the work of individuals and substance to larger structures – remain relatively unexplored. A microsociological perspective acknowledges that individuals and organizations, like Levi-Strauss' (1966) savages, pursue a science of the concrete. Individuals construct novel interpretations and actions through a process of intellectual bricolage, by dissembling and reassembling their past experiences in ways that enable them to understand and respond to new situations (Lévi-Strauss, 1966; Swidler, 1986; DiMaggio, 1997).

At the heart of this article, then, is an attempt to understand how individuals in organizations construct innovations from pieces of the very landscape those innovations ultimately reshape. The model uses case studies of one set of organizations, knowledge brokers, as a window into the relationship between processes of learning old knowledge and of creating new knowledge. Knowledge brokers work within many different domains, and routinely recombine past experiences in new ways and for new audiences (Hargadon, 1998a, 2003; Hargadon & Sutton, 1997). Studies have considered the global impact that existing technologies often have when transferred to other industries (e.g. Rosenberg, 1982; Rogers, 1995). Yet relatively few studies have attempted to understand the individual and group processes that first see, and then transform, these existing resources into new and innovative combinations in distant contexts. Neustadt and May (1986), for instance, looked at how the decision-making process in political administrations relied on their concrete understandings of past events to build new interpretations and actions in current ones. Similarly, Hargadon and Sutton (1997) applied this perspective to explain how one product development firm's ties to multiple disconnected industries enabled it to innovate by brokering technologies between them.

This article relates, within a single framework, research from multiple levels of analysis, from social structures to organizational practices to individual cognition. The goal is to direct attention to how processes of organizational learning and innovation are linked through both their embeddedness in more global contexts and their enactment locally by individuals and groups.

The larger social context creates the pre-conditions for innovation in two ways: through the recombinant nature of innovations and the fragmented nature of the larger social structure. The perspective of innovation as a recombination of past ideas, artifacts, and people is not new: Schumpeter (1934, pp. 65, 66) defined innovation as the "carrying out of new combinations" and Weick (1979a, p. 252) defined creativity as "putting new things in old combinations and old things in new combinations." Less appreciated, however, are the advantages that innovators derive from this continuity with the past. By recombining existing elements, entrepreneurs are able exploit well-developed ideas, artifacts, and even people rather than invent new ones. The recombination of existing resources is an act of innovation because, while the social world is typically viewed as a seamless web, it is fragmented into many small domains in ways that make it difficult to disentangle and recombine the resources from one domain into another (DiMaggio, 1997; Hargadon & Fanelli, 2002). Individuals and organizations exploit this fragmented social structure by *bridging* multiple domains and moving ideas from where they are known to where they are not. Such social actors occupy brokerage positions spanning otherwise disconnected subgroups (Burt, 1992a; DiMaggio, 1992) and, by learning about resources in one context and introducing them in others, they appear, and are, innovative. For example, when Elvis Presley and his producer Sam Phillips combined a popular country ballad, *Blue Moon of Kentucky*, with a Rhythm and Blues beat, they introduced the traditional sounds of R&B to a white teenage market that had little prior experience with it (Palmer, 1995). Elvis and Sam Phillips exploited the segregated structure of both society and the music industry and, by bridging two of the smaller worlds within, constructed a successful innovation from pieces of both worlds.

While the larger social context and bridging strategies explain the structural advantages that knowledge brokers hold in the innovation process, it does not explain the critical links between learning and innovation that must take place to recognize how existing resources in one domain might be valuable in new combinations elsewhere. These are the processes that link past experiences to future innovations, and these processes take place within the organization, at the level of individuals and groups.

Individuals in knowledge brokering organizations learn about the resources within each domain, capturing and storing that knowledge to use in current projects, but also for use in future projects (Levitt & March, 1988; Huber, 1991). Traditional perspectives of organizational learning describe how organizations convert their experiences into potential future responses; the model of knowledge brokering suggests this learning exhibits hysteresis. Organizations with experiences in a single domain will learn (and remember) particular knowledge in different ways than those with experiences spanning many different domains. Individuals and organizations with prior related knowledge may have greater absorptive capacity (Cohen & Levinthal, 1990), yet sociocultural studies of learning also suggest that individuals, at least, tend to learn only partially, relying on the environment to maintain the missing pieces (Bruner, 1979; Lave, 1988). Learning that takes place continually within a single domain may be more dependent on, and hence situated within, a single context than learning which spans multiple domains. Further, studies have shown that many failures in problem solving result not from the lack of appropriate knowledge but from the inability to recognize when that knowledge is appropriate to a new situation (Lave, 1988; Reeves & Weisberg, 1994; Thompson, Gentner & Lowenstein, 2000). Knowledge is contextual and, when learned, often remains entangled in its original situation and meaning (Berger & Luckman, 1967; Nonaka, 1994).

To innovate, problem solvers must disentangle the extant knowledge learned in the context of one domain in order to see how it could be valuable in another. How does old knowledge become the raw materials for new knowledge rather than remain fixed in its original context? The conversion from old to new relies on a process of analogical reasoning, in which ideas from one domain are used to solve the problems of another (Gick & Holyoak, 1980, 1983; Gentner & Gentner, 1983; Reeves & Weisberg, 1993, 1994). As Reeves and Weisberg (1994, p. 381) said, "some researchers have argued that analogical transfer is the main method for solving novel problems . . . others have adopted the stronger position that it is the only means." In organizations, this process of linking existing knowledge to new situations, of creating new combinations of existing ideas, must occur across individuals and groups, and over time.

Finally, the strategies and activities that identify novel recombinations are not enough to ensure success in the innovation process. For new ventures to succeed, entrepreneurs must also attend to building new ties that link others to these ventures for a discussion of the differential advantages of bridging and building network ties (see Walker, Kogut & Shan, 1997). As new and redundant ties emerge around an innovation, a community emerges and with it, corresponding increases in the coordinated effort, legitimacy, and social capital that turn innovations into institutions of their own (Baker & Obstfeld, 1999). Martin and Eisenhardt (2001), for example, found that successful new product development ventures that bridged multiple groups within the firm did so by building strong ties where previously only weak or no ties existed. The process of building redundant ties around an emerging innovation reshapes the network itself, often masking the structural advantages and knowledge brokering activities that early innovators pursued.

This article links organizational learning and innovation in a single model of how people share and recombine knowledge within organizations. The model draws together disparate but relevant research, and is illustrated using evidence from the case studies of organizations that act as knowledge brokers (Hargadon, 1998a, 2003; Hargadon & Sutton, 1997). Knowledge brokers present an opportunity to study the links between learning and innovation in an environment where such links are not only possible, but frequent and necessary to the ongoing work of the organization. These organizations move between multiple domains, typically as consulting firms working in a range of industries or as internal groups consulting across multiple divisions, and they innovate by recognizing how knowledge learned from working in one domain may be valuable to clients in another. In these organizations, innovation is less the exception than the rule.

## LEARNING AND INNOVATION IN KNOWLEDGE BROKERING FIRMS

Knowledge brokering organizations serve as windows into the relationship between learning and innovation because they routinely transform their past knowledge into new and innovative products, processes, and services. These organizations move between multiple domains rather than pursue centrality within any one, and this article grounds the model of knowledge brokering in examples from case studies of eight such firms (see Table 1 for a detailed description of these organizations). These firms act predominantly as consultants, working with clients in different industries, and the case studies include engineering design consultants, management consultants, and internal consulants (both management and engineering groups that consult between divisions within large firms). While the work of these organizations differs, they were chosen because they share brokerage positions in their environments and share work practices that enable them to move ideas from one domain to others (for a more detailed description of the research, see Hargadon, 1997). In knowledge brokering organizations, the activities that turn past learnings into the raw materials for future innovations become more central and visible because these organizations experience the diversity of ideas, artifacts, and people in different domains, and are often able to identify valuable new combinations of these resources.

This can perhaps be most easily seen in how one such knowledge broker, Design Continuum, developed an innovative solution for a new client. In 1988, Reebok approached Design Continuum to develop a successful response to Nike's new Air™ technology, a heel cushion and "active energy return system." Instead, Design Continuum created the Pump™. The Pump™ concept produced a form-fitting shoe by incorporating an inflatable air bladder into the sides of an athletic shoe. This solution first emerged when one of the designers, who had previously designed an inflatable splint, recognized how such splints might prevent injuries by building ankle support into a basketball shoe. Another on the team had worked on medical equipment and, familiar with IV bags, saw how these small sealed bags could be modified to provide the oddly shaped air bladders necessary to make this "splint-in-a-shoe" concept work. Still, the

***Table 1.*** List of Knowledge Brokering Organisations Used as Illustrations.

**Engineering Design Consulting Firms**

**IDEO Product Development**

IDEO's over 300 employees provide engineering and design services to clients in over 40 industries and have contributed to the design of over 3,000 new products and, at any one time, are involved in approximately 50 development projects. Examples of innovative solutions include:

- A blood analyzer that integrates client's chemical analysis equipment with technical components from computer industry.
- The mechanical whale for the movie "Free Willy" that combines traditional special effects with ideas from computers, hydraulics, and robotics.

**Design Continuum**

Design Continuum, with over 90 employees, has worked for over 100 different clients in dozens of industries. Examples of innovative solutions include:

- Pulsed lavage emergency room wound cleanser that integrates low-cost pump from toy squirt gun with medical product design guidelines and materials
- Reebok pump shoe that combines client's shoe designs with inflatable splints and technologies (and suppliers) from IV bag manufacturing.

**Management Consulting Firms**

**AndersenConsulting**

AndersenConsulting's 38,000 employees provide strategic business and technology solutions to clients. Examples of innovative solutions include:

- Demand chain solution provided to client combining internet infrastructure with SAP inventory control software.
- Solution for health care company adapted from previous banking solution combining internet and human resource software.

**McKinsey & Company**

McKinsey & Company, with 4,000 employees, offers strategic business solutions to clients in almost all sectors of business. Examples of innovative solutions include:

- A Strategic planning model for client facing deregulation built on problems learned working with past clients in another, previously deregulated industry.
- A purchasing effectiveness program for one client built from an awareness of past solutions and problems with cost-cutting projects of previous clients in other industries.

**Within Multi-divisional Firms**

**Hewlett-Packard: Strategic Processes and Modeling Group**

Hewlett-Packard develops and manufactures high-technology products for wide variety of industries. The Strategic Processes and Modeling Group works with the 150 or so divisions within the firm to optimize their manufacturing and distribution processes. Examples of innovative solutions include:

- Supply chain management model continually combines problems and solutions of previous application environments.
- Inventory costing model combined marketing strategies from consumer goods industries with traditional inventory models.

*Table 1.* Continued.

**Within Multi-divisional Firms – Continued**

**Boeing Company: BCAG's Operations Technology Center**

Boeing designs and builds commercial and military aircraft, helicopters, space and missile systems, and electronic and software systems. The Operations Technology Center works with the many factories of the Boeing Commercial Airplane group to support and advance their manufacturing process. Examples of innovative solutions include:

- Metal stamping process improvement built from process solutions in other factories and from incorporating external materials.
- Composite materials production processes transferred technological knowledge from military divisions to within Boeing's Commercial Airplane Group.

**Historic Studies of Engineering Firms**

**Edison & Co.'s Menlo Park Laboratory**

Thomas A. Edison and a team of engineers operated a laboratory in Menlo Park, New Jersey, from 1876–1881. During that time they developed products for industries such as the telegraph, telephone, railroad, mining, and electric lighting. Examples include:

- Fundamental breakthrough in telephone microphone built on specific ideas learned from work on the Atlantic cable and the high speed telegraph.
- Original phonograph combined ideas from repeating telegraphs, telephone, and electromotograph.

**Elmer Sperry**

During the 1880s and 1890s Elmer Sperry and his engineering staff developed products for the electric lighting industry and for the machining industry, but were best known for their pioneering work in feedback controls, or cybernetics, such as gyroscopic controls of ships and planes. Examples of innovative solutions include:

- Automatic feedback control mechanisms for ships that combined linkage systems with gyroscope technologies.
- Auto-pilot and auto-stabilizers for airplanes built from initial development of gyroscopic control of ships at sea.

problem remained of how customers could easily inflate and deflate the shoe. Others in the firm became involved, several having worked with diagnostic instruments and the little pumps, tubing, and valve components that made up those products. When they recognized how such components could be adapted to fit in the tongue of the shoe, the major ideas were in place.

Within six months of these ideas coming together, the engineering design was complete and, six months later, the Reebok Pump™ shoe was introduced to the market. In the following year it accounted for over $1 billion in revenue in the highly competitive athletic shoe market and gained wide praise in the business press for its creativity. The series of events that created to the Reebok Pump™ shoe idea at Design Continuum illustrate the link between organizational learning and innovation. Within the project team, a few people had learned about the client's demands, another about inflatable splints, another about IV bags, and others about pumps. Innovation involved first connecting the knowledge of these resources across members of the organization – without any one participant knowing which of their previously irrelevant experiences might be made relevant and by whom. And then connecting these ideas to Reebok, in part through design and in part by making the IV bag manufacturer a supplier of inflatable bladders for basketball shoes. Understanding the process of knowledge brokering means understanding how past knowledge of splints, of medical IV bags, of pumps and valves – all held by different people in the organization and elsewhere – became valuable for designing and building a sneaker.

A knowledge broker's ability to routinely transform old knowledge into innovative solutions depends both on the organization's experiences in the larger environment and on the activities of the individuals and groups engaged in the work. To describe how these external conditions and internal activities make possible organizational outcomes that are new combinations of existing knowledge, this article presents a model of the knowledge brokering process.

This model links organizational learning and innovation through five steps (summarized in Fig. 1). The first step, *Access*, describes the structural preconditions that create the potential for innovation. Of particular relevance are the recombinant nature of innovation and the fragmented nature of the social world. The second step, *Bridging*, describes the strategies of individuals and organizations that move resources between these worlds. Knowledge brokers, by working within multiple domains, gain access to the ideas, artifacts, and people that reside within one domain yet may be valuable in others (Burt, 1992a, b; DiMaggio, 1992). How these existing resources become innovative solutions to new problems depends on what happens within the firm. The three remaining steps of the model describe the actions of individuals within these organizations that transform their knowledge about these extant resources into the raw materials of new innovations. These steps reflect the interdependence of processes of organizational learning (March & Simon, 1958; Cohen & Levinthal, 1990; Huber, 1991; Walsh & Ungson, 1991) and organizational innovation and creativity (Amabile, 1988, 1995; Kanter, 1988; Fiol, 1996). *Learning* (step 3) describes the activities that individuals engage in to bring knowledge from a particular domain into the organization. In this step, individuals learn about the solutions that exist within a domain and they learn about the problems that exist – and are defined – within that domain. *Linking* (step 4) describes how people recognize how old resources can address new and problematic situations by sharing their knowledge within the organization. *Building* (step 5) describes how organizations move from innovative ideas to

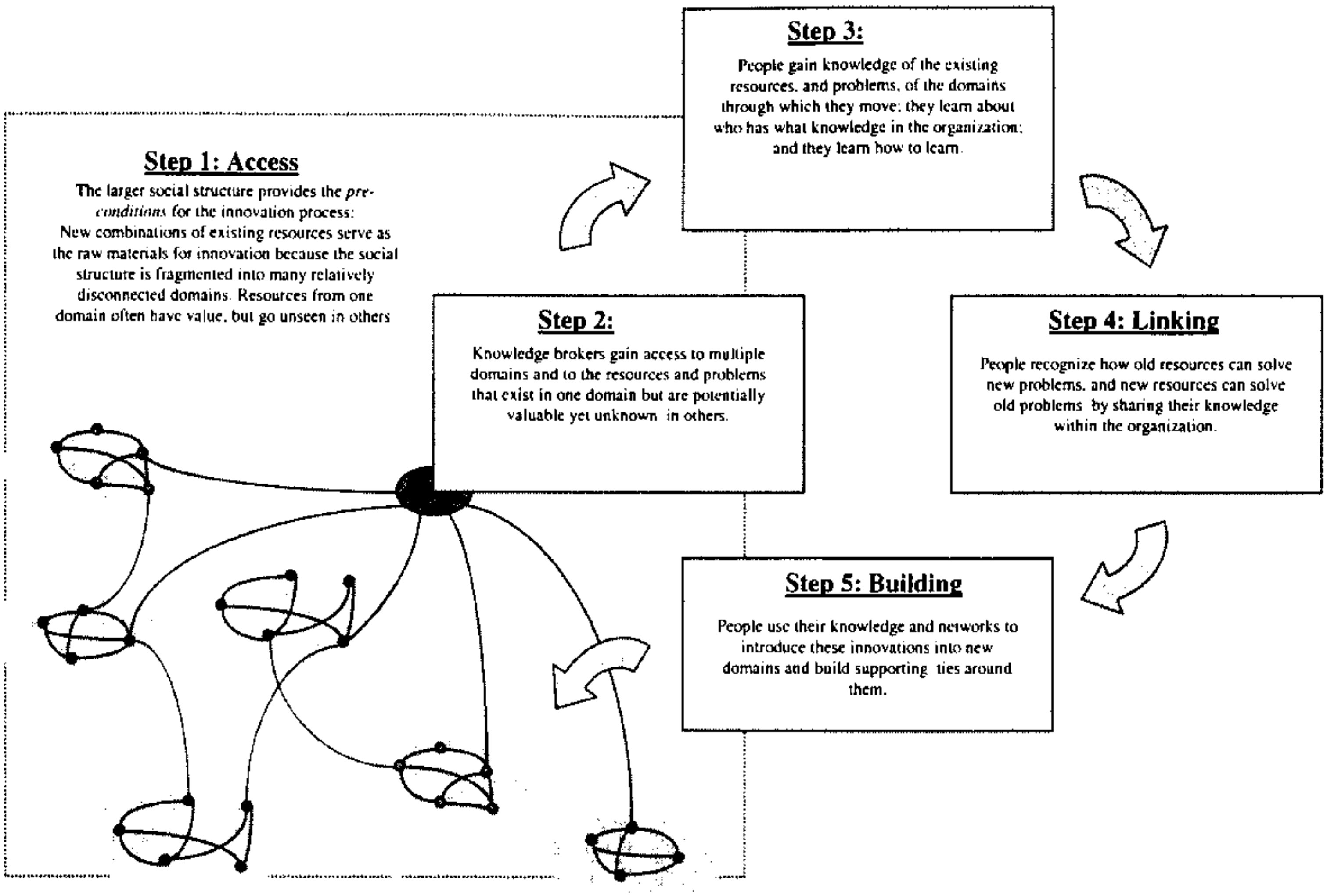


*Fig. 1.* A Process Model of Knowledge Brokering.

accepted innovations by building new network ties, embedding the emerging recombination within a new domain.

### *Access: The Structural Preconditions for Innovation*

To consider the processes that link past learnings to innovations, it is first useful to clarify the role that existing knowledge plays in generating new knowledge. Two aspects of the external environment are central pre-conditions for the process of knowledge brokering: the recombinant nature of innovation and the fragmented nature of the social landscape.

#### *Recombinant Innovation*

Many definitions of innovation recognize the presence of old ideas, combined in new ways. Joseph Schumpeter, for example, described innovation as, "to produce other things, or the same things by a different method, means to combine these materials and forces differently" (Schumpeter, 1934, pp. 65, 66). Similarly, Usher (1929, p. 11) described technological change as the "constructive assimilation of pre-existing elements into new syntheses," and Ogburn (1922; in Basalla, 1988, p. 21) defined social change as a result of "combining existing and known elements of culture in order to form a new element." More recently, management scholars have focused on how this innovation process recombines existing competencies within the firm (Henderson & Clark, 1990; Hargadon & Sutton, 1997; Brown & Eisenhardt, 1998). Rather than highlighting discontinuities in the origins of new technologies, this perspective highlights how new ideas are built from existing ones.

Yet the recombinant nature of innovation is often downplayed in efforts to identify and describe the events that produce revolutionary change (Rosenberg, 1979). As a result, innovations are variously differentiated with such terms as *revolutionary* vs. *evolutionary, radical* vs. *incremental, discontinuous* vs. *continuous* (Rosenberg, 1982; Abernathy & Clark, 1985; Tushman & Anderson, 1986; Tornatzky & Fleischer, 1990; for a review see Wolfe, 1994). These descriptors often confuse the discontinuities of an idea's impact with the discontinuities of its origins. As Basalla (1988) has argued, revolutionary innovations often come from very evolutionary origins.

The development of mass production at Ford Motor Company, for example, demonstrates the role that recombinations of existing ideas, artifacts, and people play in the development of revolutionary innovations (Hounshell, 1984; Hargadon, 2003). At Ford, mass production was made possible through the combination of four technologies that were well-developed already: interchangeable parts, continuous-flow production (dedicated machinery), the assembly line, and the electric motor. Hounshell (1984) described how Ford brought together existing technologies from granaries, breweries, foundries, bicycles, canning, and meatpacking to create the system of production that would revolutionize the auto industry and rapidly become the organizing model behind manufacturing organizations. In the words of Max Wollering, whom Ford hired from the machine tool industry, "There was nothing new [about interchangeability] to me, but it might have been new to the Ford Motor Company because they didn't have much experience along that line" (Hounshell, 1984, p. 221). Similarly, William Klann, who headed Ford's engine department, once described the origins of continous flow production: "We combined our ideas on the Huetteman and Cramer grain [conveying] machine[ry] experience, and the brewing experience and the Chicago stockyard. They all gave us ideas for our own conveyors" (Hounshell, 1984, p. 241). Ford's mass production was revolutionary but, in many ways, that revolution was constructed from ideas that were already working in other industries (Hargadon, 2003).

The development of Polymerase Chain Reaction (PCR) technology also reveals the continuous origins of a revolutionary innovation. PCR is to molecular biology what Ford's mass production was to the modern factory, a chance for scientists to mass-produce particular strands of DNA. Kary Mullis is considered the inventor of PCR, and was awarded the Nobel Prize for his work. He once described his achievement:

> In a sense, I put together elements that were already there, but that's what inventors always do. You can't make up new elements, usually. The new element, if any, it was the combination, the way they were used . . . (Rabinow, 1996, pp. 6, 7).

PCR has already triggered discontinuous changes in the development and manufacture of new medications in the pharmaceutical industry (Barley, Freeman & Hybelss, 1992; Powell & Brantley, 1992). And these changes were based in the continuity of the ideas Mullis used to construct his new, biochemical manufacturing technique, ideas that were already well developed and relatively accessible to laboratories throughout the world (Rabinow, 1996).

The impact of any innovation derives in part from the prior existence of its components. This prior existence enabled Ford to exploit sixty years of learning-in-use in the machine tool industry and in the foundries, breweries, granaries, and meatpacking plants where new equipments and methods were being developed (Rosenberg, 1963; Hounshell, 1984; Hughes, 1989). Indeed the time spent moving down the learning curve can be considerably shortened when recombining known elements in new ways. Ford's first experiment with the assembly line, for example, took place in the Magneto Assembly room and, that first day, brought an almost 40% improvement in productivity. By the end of the first year, productivity had increased over 400%. Ford's version of mass production may have succeeded precisely *because* it hinged on the recombination of existing ideas, artifacts, and people. Similarly, PCR allowed scientists to exploit the existing hardware, techniques, and technicians that comprised the Polymerase Chain Reaction technology. Such recombinations can have revolutionary impacts because of the social structure that develops those ideas within single domains and prevents them from flowing easily to others. The next section explicates the fragmented structure that makes old ideas, developed in one context, new and valuable elsewhere.

*Small Worlds*

From a network perspective, the conditions for recombining existing ideas, artifacts, and people in new ways exist because the social world is not a seamless web. Rather, it is fragmented into many isolated, and isolating, domains (Swidler, 1986; DiMaggio, 1997). The concept of domains describes sets of resources that are densely connected *within* but loosely connected *across* domains. These resources are often treated as social networks, but doing so denies the interdependent roles of shared ideas (both institutionalized and emerging) and existing artifacts. Knowledge resides within ideas, artifacts, and people, and any discussion of how knowledge diffuses within and across domains must recognize the roles of ideas and artifacts as vectors in this process (Allen, 1977; Star & Griesemer, 1989; Star, 1995). Fleming (2001) and Fleming and Sorenson (2001), for example, trace the flow of ideas in patents, which serve as artifacts that contain (and communicate) knowledge about useful combinations of existing resources. In this way, the network perspective of knowledge brokering derives from research in both social network theory (Burt, 1992b; Nohria & Eccles, 1992) and actor network theory (Law, 1989; Law & Hassard, 1999). Domains identify communities with shared knowledge, similar to Burt's (1983, p. 180) description of actors that "know one another, are aware of the same kinds of opportunities, have access to the same kind of resources, and share the same kinds of perceptions." The small world phenomenon (Watts & Strogatz, 1998; Watts, 1999) – that we are all only a few degrees of separation from everyone else – is continually surprising because each domain, for its inhabitants, is experienced as its own small world.[1]

The same small worlds conditions exist within multidivisional organizations. Organizational structures reflect the separation between divisions, and between groups within divisions. As Salancik (1995, pp. 346, 347) points out, "all interactions occur in a context of institutions, including rules and roles. Organizational policies impose some of these: units are explicitly directed to interact with one unit but not others or are instructed to report to one unit rather than another." Informal norms, such as competition for scarce resources or market opportunities, also reduce interactions between groups, as do the development of specialized languages and perspectives within groups (Dougherty & Hardy, 1996; Bechky, 1999). As a result, domains emerge within organizations that reflect and reinforce the relatively few interactions between them. Under these conditions, ideas about organizing, valuable technical artifacts, and skilled individuals in one domain often go unknown and untapped in others.

Domains are constructed from the habitualized actions, interactions, and beliefs of the inhabitants (Giddens, 1979, 1984; DiMaggio, 1992). Over time, they develop what Friedland and Alford (1991, pp. 248, 249) describe as "institutional logics" that are "symbolically grounded, organizationally structured, politically defined and technically and materially constrained." The repeated interactions that arise from the dense interrelations within domains create socially shared but individually held schemas and scripts (DiMaggio, 1997; Hargadon & Fanelli, 2002). Domain-specific schemas and scripts constitute an individual's portfolio of available understandings and appropriate actions in that context. These portfolios constrain actors to only appropriate actions for their perceived roles but, equally, enable and legitimate the actions of those roles.

In this way, the conditions for recombinant innovation stem not from de facto domains, but rather from the beliefs and actions that constitute and artificially constrain the behavior of their inhabitants within each domain. Small worlds simultaneously constitute and constrain individual and organizational cognition and action. The process of creativity and innovation, from a small worlds perspective, is the process of moving ideas from where they are known to where they are not. As an example, one of Edison's early products, a stock-ticker that transmitted real time market information, worked equally well after only minor modifications as a fire alarm. This is also reflected in a truism of the art world: that one is only as original as the obscurity of one's source. Picasso understood this when he said, "Mediocre artists borrow, great artists steal." Similarly, the science fiction author William Gibson, when asked how he developed his futuristic visions, replied "The future is already here, it's just unevenly distributed." He would find interesting new technologies used in one domain, and imagine worlds in which everyone used them. To suggest people think "out of the box" is to suggest people can think without prior schemas and act without prior scripts. From a small worlds perspective, people don't think out of the box, they think in boxes others can't see.

The larger social structure creates the pre-conditions for innovation by isolating potentially valuable ideas, artifacts, and people within small worlds. When these resources move, in combinations with others, into other domains, they become novel for their unfamiliar origins and valuable for their established elements. And while the movement of resources, and their subsequent impacts, can often be seen at a global level – they are the product of the concrete strategies and actions of individuals and organizations.

### *Bridging: Exploiting Small Worlds in the Pursuit of Innovation*

The structural conditions that enable recombinant innovation occur when ideas in one domain are valuable but unknown in others. As a result, individual and organizational access to the ideas, artifacts, and people of disparate domains exerts a complex influence on the innovation process. Previous research has relied on a social network perspective to explain how firms profit by transferring solutions across domains (Burt, 1992a; Hargadon & Sutton, 1997). By bridging otherwise disconnected domains, brokers benefit by moving resources from one group to another (Gould & Fernandez, 1989; Burt, 1992a; DiMaggio, 1992; Padgett & Ansell, 1993). Those resources, in new combinations, often appear (and are) innovative in those other domains. Elmer Sperry was a late 19th century contemporary of Edison whose pioneering work in feedback control mechanisms made him the father of modern cybernetics. Like Edison, he acted as a knowledge broker (Hughes, 1971; Hargadon, 1997, 1998). Sperry understood the advantage of moving between many small worlds,

> If I spend a lifetime on a dynamo I can probably make my little contribution toward increasing the efficiency of that machine 6 or 7%. Now then, there are a whole lot of [industries] that need electricity, about 400 or 500%. Let me tackle one of those (Hughes, 1989).

Sperry's strategy was to introduce his knowledge of electro-magnetic technologies to new domains rather than to specialize in just one. And this was an effective strategy, as Sperry's professional life coincided with the rapid diffusion of electricity and electro-mechanical solutions. In 1899, electric motors accounted for 5% of the total installed horsepower in American manufacturing; in 1909, the number was 25%; in 1919, 55%; in 1929 over 80% (Rosenberg, 1982). Founder and Chairman of IDEO Product Development, David Kelley, stated this more simply when he said his firm's strategy was "to be the high-tech firm to low-tech firms." Both Sperry and IDEO exploited the possibilities that a fragmented landscape provides in the innovation process.

The structural advantages that shape innovation come into sharper focus, however, when looking at firms that engage in this process regularly. Hargadon (1997, 1998) describes how Thomas Edison and his Menlo Park, New Jersey Laboratory exploited the process of recombinant innovation to generate a stream of patented innovations (over 400 patents within a six year period). By combining ideas they learned while working in the telegraph industries, Edison's lab produced innovations in stock tickers, fire alarms, mimeographs, and telephones. The mimeograph pen, for example, was Edison's first commercial success and was the result of re-using a component of an automatic telegraph machine which rapidly punctured paper to record messages (Conot, 1979). While the mimeograph is now obsolete, this design remains in use today, with only minor modifications, as the tattooing needle (Morton, 2002). Similarly, lessons learned in building an atlantic cable gave Edison's team insights into designing a microphone for the telephone. Millard (1990) described how any one development project often offered valuable spillovers that Edison would exploit in other projects. Should any insights emerge from one project, Millard (1990, p. 48) explained, "If it provided the key to another problem in a totally different project, [Edison] was prepared to quickly exploit it. The new lab was built with this kind of flexible innovation in mind."

A network perspective depicts brokers as conduits linking multiple domains, and knowledge brokering as a strategy of pursuing weak ties across many domains rather than strong ties within just a few (Granovetter, 1973). Yet the evidence suggests that knowledge brokering involves more than simply transferring ideas across domains. From a network perspective, brokers overcome the structural isolation between domains. But when brokers transfer ideas across domains, they must also overcome the cognitive constraints that exist in the domains from which knowledge comes and to which it is applied. Knowledge brokers often recognize, at least implicitly, that their network position enables them to overcome the local beliefs and actions of any one domain. For example, DiMaggio (DiMaggio, 1997, p. 280) points out that "When persons or groups switch from one domain to another, their perspectives, attitudes, preferences, and dispositions may change radically." Similarly, Gian Zaccai, CEO of Design Continuum, believed that working in different industries "frees you from the dogma of any one industry and their firm belief in the links between problems and solutions," such as when the Reebok Pump™ team members came to realize that IV bags had relevance in the context of athletic shoes, or inflatable splints. Edison recognized the dangers of believing the truths of any one domain: "When I start to experiment within anything . . . I don't want to know what has been done [in that field]" (Conot, 1979, p. 128). At the time, Edison's work on the incandescent light was called "sheer nonsense" by leading scientists and Edison was accused of "the most airy ignorance of the fundamental principles of electricity and dynamics." And these judgements appeared to follow Edison across the many industries through which he wandered during his career (Conot, 1979).

The existence of multiple domains creates the conditions for firms to routinely innovate by brokering knowledge from where it is known to where it is not. Yet such a perspective offers little explanation of how knowledge about the resources from any one domain enters into firms or how it ultimately emerges again as innovative new products or processes. If domains isolate and constrain the use of knowledge, how do the individuals and teams working in any one domain recognize the value of ideas, artifacts, and individuals from across other domains? A complete model of knowledge brokering must explain how the individuals and groups acting within knowledge brokering organizations turn the broad-ranging learning of their past into innovative new ideas for other, future contexts. Access describes those external conditions – the habitualized actions and beliefs of others – that enable knowledge brokers to routinely innovate by importing useful yet unvalued knowledge. Bridging describes those strategies that move firms between small worlds. Yet while such conditions explain the potential for innovation they are incomplete in describing the process that exploits these conditions. As Cohen and Levinthal (Cohen & Levinthal, 1990, p. 128) argued, "the ability of a firm to recognize the value of new, external information, assimilate it, and apply it to commercial ends is critical to its innovative capabilities." Moving between many small worlds does not ensure that an organization will recognize their resources nor recombine them in novel ways. The next steps blend findings from organizational learning, innovation, and cognitive psychology to explain how the knowledge brokering process unfolds within these organizations as their old knowledge becomes new in a new context.

### *Learning: Converting Experience Into Knowledge*

*Learning* describes the set of activities that individuals and groups in organizations engage in to extend their ability to comprehend and act within their environment. For many, organizational learning represents the process by which lessons from experience and the environment come to be encoded into rules, routines, technologies, and operating procedures that become subject, later, to mindless (and potentially inappropriate) application (March, 1972; Weick, 1979b). And in stable environments, such learning processes are relatively effective at improving performance (Wright, 1936; Epple, Argote & Devadas, 1991; Tyre & Orlikowski, 1994). However, a focus on encoding knowledge in mindless responses to established stimuli downplays the role of learning in accumulating the raw materials for generating novel comprehension and action. Research suggests this learning involves four distinct activities:

(1) learning about the existing resources of each new domain;
(2) learning the related problems in that domain;
(3) learning what others in their own firm know; and
(4) learning how to learn.

Learning of existing resources and their existing combinations is the traditional focus of much of the literature on organizational learning (Levitt & March, 1988; Huber, 1991; Walsh & Ungson, 1991; Weick, 1991). Weick (1991), for instance, describes learning as gaining awareness of a new response to a given stimulus. Learning enables organizations to function effectively in their current tasks, and also to apply their experiences to similar problems in the future. However, not all learning is the same. Socio-cultural approaches to learning have found that the social and physical context in which learning takes place significantly shapes the process, in particular because such learning often relies on situational cues to recall or replace particular knowledge (Bruner, 1979; Lave, 1988; Lave & Wenger, 1991). Such learning is difficult to recall out of context, absent the complementary knowledge that resides there. Lave (1988), for example, showed that mathematics skills are learned differently in the context of grocery shopping, and differently by those familiar with that context, than in classrooms. Tyre and von Hippel (1997) showed that organizational learning was similarly situated in context. Studying the introduction of new production machinery into factories, they observed how different adaptive responses emerged from problem solvers in the differing contexts of the laboratory or the factory floor.

Because of the situated nature of learning, organizations that learn through interactions and experiences within a single domain will differ from those that learn through interactions and experiences while moving across a range of domains. The learning process of knowledge brokers, for instance, does not have the goal of codifying knowledge for use again in similar circumstances, nor do the participants in the process identify themselves with particular resources or expect to use them in the same ways in the future. Instead, knowledge brokers tend to acquire knowledge with an eye towards its usefulness in often very different (but as yet unknown) situations. An IDEO engineer, for example, referred to this type of learning as throwing a bunch of tools into his tool box. He "remembered the tools, but not where they came from." Similarly, in attempting to learn about a particular area, knowledge brokers are less inclined to restrict their search based on domain-specific schemas identifying relevant and appropriate resources. In this way, knowledge brokers learn about resources in ways that are grounded in concrete details but not bound to the context in which they are learned.

Design Continuum offers another example of how past experiences shape the process of learning the relevant resources for a new problem. When Design Continuum was given a complex new kitchen faucet project, an engineer sought existing solutions from wherever the team could think to find similar valves and uses:

> The first thing we did was purchase all sorts of valves we could think of to see how they were implemented. Then it was really combining those technologies that allowed us to innovate this new way, and the valve we came up with is really cool.

What made this learning process effective was the delighted response of the faucet company to the variety of valves she found – having been in the business for over fifty years, they thought they knew all the valve designs worth knowing.

In the second type of learning, knowledge brokers increased their range of potential responses to the demands of current and future projects by learning about the problems that exist within each domain they work in. Problem definitions are, as Weick argued (1995, p. 89), "constructed and imposed, but not in total disregard of one's context and its constraints." Similarly, Lave (1988, p. 42) suggested, "Whether to have a problem or not, and the specification of what constitutes the problem, are commonly choices made by problem solvers." Problem definitions act as descriptions of particular conditions and, more significantly, as only one of several possible descriptions of any situation. The possibility of defining a problematic situation in different ways is an important aspect of any problem-solving experience. And learning a range of existing problems increases the variety of definitions that can be applied to future situations (Conant & Ashby, 1970; Weick, 1995). There is also an interaction between the variety of resources one has previously learned and the ability to recognize new problems. Hutchins' (1990, p. 205) description of problem solving onboard a ship shows that problems are often defined in terms of the tools available for their resolution: "each tool presents the tasks to the user as a different sort of cognitive problem requiring a different set of cognitive abilities or a different organization of the same abilities." Individuals and firms that have worked in many different domains may find it easier to learn new ways for defining problems based on their variety of tools they have picked up on the way.

By working in many different domains, knowledge brokers are able to learn many different ways to see situations that inhabitants of a single domain take as given. In another project at Design Continuum, for example, a team was asked to improve the tools and techniques used in knee surgery. A manager at Design Continuum explained their process, "We start off by visiting users, by understanding what they do, what the problems really are, not what they just tell you the issues are . . . In reality, you find out there are other things." The engineers went to a convention for surgeons where they reserved a lecture room, chilled to 50 degrees, and brought in 12 cadavers, in order to have the doctors re-create the surgical process in a way that allowed the engineers to watch and talk with them. Designers noticed that surgeons had developed elaborate habits to unwittingly make up for what one engineer described as the "missing third arm"; this enabled them to develop a new surgical tool that allowed doctors to hold, rotate, and operate on the kneecap. By pursuing alternative problem definitions, knowledge brokers are able to recognize problems in ways others might not and, hence, recognize areas for innovation that others have missed.

A third type of learning involved in the process of linking old knowledge to new problems is learning who knows what in the organization. Most knowledge enters the organization and resides within individuals (Huber, 1991). That knowledge has value to the extent that others, facing a problematic situation that would benefit from it, can learn who else in the organization knows it. Without negating the importance of information processing at the individual level, social psychologists and others have begun exploring the implications of viewing cognition as a fundamentally social activity. Wegner and associates, for example, have shown how individuals in close relationships take on a shared memory process, transactive memory, which relies on differentiated responsibilities for remembering parts of past experiences and an interactive process for cueing, retrieving, and assembling those parts into a coherent whole (Wegner, 1987; Wegner, Erber & Raymond, 1991).

This knowledge exists, for example, in the local recognition of the "expert status" of others (Geertz, 1973; Sutton & Hargadon, 1996). At Design Continuum, for example, an engineer described how "people are definitely known for their strengths that other people are aware of" while, at IDEO, a designer explained how "the model is you become a real expert and you're recognized around the company as being an expert in that particular field." Knowing who knows may even be an informal role in many organizations, and a formal role in several. For example, Edison was known for his ability to provide this perspective; he "never lost track of an experimental project [conducted in his lab] and could remember previous experiments that might provide useful information" (Millard, 1990, p. 37). McKinsey even has formal roles, individuals whose job is specifically to know what others know and help make connections (Hargadon, 1998). However, learning who knows what involves more than learning who to go to for particular expertise or what it is they know. Rather, it is learning who can help elicit past experiences – in themselves or others – that will uncover the innovative potential of past resources for current projects. One McKinsey consultant, for example, described how he often chose to spend more time talking with less knowledgeable but more attentive junior colleagues about a problem he was facing than attempt to contact a more knowledgeable but more inaccessible senior colleague.

Finally, knowledge brokers engage in activities that improve their ability to learn from each new project and each new domain in which they find themselves. This meta-learning is similar to Argyris' (1993) notion of double-loop learning in organizations, in that knowledge brokers have developed their abilities to reflect on and hone their learning activities. IDEO Product Development offers one valuable window into these learning strategies. For instance, IDEO managers have knowingly underbid projects for clients in new domains, such as the design of railroad cars and stations, or cruise ships, in order to expose themselves to the ideas, artifacts, and people of these different worlds. IDEO has also gained considerable attention for its rapid and frequent prototyping of emerging design concepts (Schrage, 1993, 2000; Kelley & Littman, 2001), and the philosophy behind building the organizational capabilities to test emerging ideas: "Fail early, Fail often."

Prototyping involves building and testing iterations of the final solution, or component parts of the solution, as a design evolves over the course of a project (Eisenhardt & Tabrizi, 1995). These iterations are useful in uncovering unforeseen problems, as Edison (Conot, 1979, p. 284) once explained:

> It has been so in all my inventions. The first step is an intuition – and comes with a burst, then the difficulties arise. This thing gives out and then that – "Bugs" – as such little faults and difficulties are called, show themselves and months of anxious watching, study, and labor are requisite before commercial success – or failure – is certainly reached.

The move from novel concept to working prototype offers many lessons about the working details of a new technology or concept since, as a Design Continuum manager said, "that particular combination of parts has never existed before, so past experience doesn't really apply [anymore]." While the "basic principles" will apply, work remains to modify the new combination to fit the setting.

Prototyping tests the validity of new ideas, but it also reinforces the understanding within an organization that learning resides in doing. In attempting to implement the ideas they have already developed, Knowledge brokers learn of new solutions, a process Rosenberg (1982) described as learning-by-using and that Cohen and Levinthal (1990) argued is critical to a firm's absorptive capacity, or ability to exploit emerging technologies. Jerome Bruner (1979) distinguishes this as "knowing how" rather than "knowing that," the difference between knowing *how* to ride a bicycle and knowing *that* a bicycle can be ridden. In turning innovative concepts into finished products or processes, individuals gain an intimate working knowledge of the capabilities and limitations of the ideas, artifacts, and even people they are working with. Similar to situated learning (e.g. Lave, 1988; Lave & Wenger, 1991), learning by doing through multiple prototypes is a quicker way to learn than less participative and more cognitive strategies. Schon (1983) described this process as a reflexive conversation between the designer and the environment. Participants gain a deeper awareness of the problems and solutions of a particular domain because each "experiment aimed at testing a particular hypothesis or achieving a particular technological effect repeatedly produces unexpected phenomena which trigger new hypotheses, goals, and questions" (Schon, 1983, p. 177). For example, the IDEO methodology handbook, used to guide new designers, advises them to "use the first prototype to discover the hidden problems in the project." And in the process of turning their new ideas into reality, knowledge brokers learn more about the solutions and problems they are working with, learning that contributes potentially valuable ideas for use in later projects. Edison's laboratory, while testing a potential solution for the Atlantic telegraph cable, discovered conductive properties in carbon that later led them to develop a revolutionary microphone technology, one that made the telephone commercially viable (Conot, 1979).

The learning activities of knowledge brokers entail more than just acquiring knowledge of existing resources within a particular domain; these organizations also learn when their members experience the problems that reside in those domains, they learn what others in the organization know, and the learn how to learn. Perhaps most important, however, is the interaction between these learning activities over time and across domains. Learning about new resources and problems often gives new meanings to their past knowledge, particularly when these experiences are shared across the organization. Conversely, past knowledge shapes the way individuals, project teams, and organizations learn about new resources and problems: giving new meaning to their experiences in previous domains. Taken together, this learning process accumulates knowledge of the extant resources and problems of different domains in ways that enable it to become the raw materials for innovation.

### *Linking: Using Past Knowledge to Solve Current Problems*

Learning builds a rich and diverse knowledge base into these organizations, yet past problems and solutions enter entangled in their original context and often end up in different corners of the organization. One R&D manager in Boeing's Ops Tech group described the problem well:

> There are cases where the person who has the knowledge is sitting right next to you and it goes unnoticed and you plow a lot of ground that you didn't necessarily have to. There's still a lot duplication of effort. There just isn't any way that I know of to make all knowledge that has ever been done on something available to the person at the time in which they need it. It's all a matter of getting the right knowledge into the right hands at the right time.

Linking describes those activities of individuals and groups that lead them to recognize how past learning can apply to the current situation, getting at least some of the right knowledge into the right hands at the right time. Within knowledge brokering organizations, individual problem solvers link their inventory of existing problem definitions and solutions to current situations through a process of analogical reasoning.

Analogical reasoning involves recognizing links between a current, problematic situation and recalled past problems and their solutions. Framing the current situation (the target problem) in terms of a past problem (the base analogue) identifies a set of past solutions that can be adapted to fit the new situation (Gick & Holyoak, 1980, 1983; Gentner & Gentner, 1983; Reeves & Weisberg, 1993, 1994). To this day, we screw in light bulbs the way we do because one of Edison's lab assistants saw a similarity between the problem of keeping the newly developed light bulbs in their sockets and the solution of the screwtop cap that keeps a kerosene bottle closed. As another example, a project at Design Continuum involved a pulsed lavage, a medical product used in emergency rooms for cleansing wounds, that had to provide a pulsed flow of saline solution, had to meet medical product guidelines for cleanliness and safety, and had to be low-cost and disposable. The design team recognized similarities between the demands of the pulsed lavage project and those of a previous product they had developed years earlier, a battery powered squirt gun. On the surface, an emergency room tool and a children's toy seem unrelated. But by recognizing the non-obvious similarities between the requirements of the two products, Design Continuum's engineers were able to rapidly combine the low-cost electric pump and battery of the toy squirt gun with the materials and design guidelines of medical products to develop a successful new pulsed lavage.

The process of analogical reasoning works in part because it allows problem solvers to consider new definitions of the problems they are facing by linking their current situation to ones they have seen before. As Schon (1983, p. 40) described, "problem-setting is a process in which, interactively, we name the things to which we will attend and frame the context in which we will attend to them." Framing involves "embedding observed events in a context that gives them meaning" (Beach, 1997, p. 17). The framing of problematic situations provides an interpretation of the problem at hand and identifies a set of solutions normally associated with that problem, and it does so by interpreting the problematic situation through analogies to previously known problems. A McKinsey partner described her work:

> I've done product market strategies in the chemicals world, in the medical device world, in the foods business. And you begin to see how challenges are parallel. It's often helpful, in working with clients, to bring those analogies out and say 'Gee, by the way, this problem you're facing is the same one we faced when working with frozen foods.'

Throughout the problem-solving process, knowledge brokers are drawing on their awareness of past problems and solutions, making analogic links between those existing ideas and the demands of the current project.

Neustadt and May (1986), Schon (1993), and Hargadon and Sutton (1997) have argued that analogies play a critical role in organizational problem solving because they allow problem solving groups to create innovative solutions by linking their inventory of past experiences to the current situations they face. These studies suggest that analogical thinking plays a central role in turning an organization's existing knowledge into novel combinations. They also suggest it does so in ways that differ from the mere aggregation of individual-level analogical reasoning. Often one person knows the current project's demands while another has knowledge of non-obvious but ultimately relevant past problems and solutions. In these cases, the analogic connections occur across people through an evolving dialogue, rather than within a single individual. At McKinsey, for example, a partner described how a group discussion helped to shape her definition of the problem by allowing her to identify and tap into the similar experiences of others. Similarly, a manager at Hewlett-Packard's SPaM Group saw the significance of teamwork in terms of their ability to pool their knowledge in ways that connected one person's problem to another's solution. The nature of these group interactions highlight the importance of *how* knowledge is made available to people within the organization.

The concept of a collective analogical reasoning draws from research into group and organizational cognition. Weick and Roberts (1993) outlined the concept of collective mind as a means for understanding how individuals working together perform effectively in high-reliability organizations, such as aircraft carrier flight decks. This perspective focused both "on individuals and [on] the collective, since only individuals can contribute to a collective mind, but a collective mind is distinct from an individual because it inheres in the pattern of interrelated activities among many people" (Weick & Roberts, 1993, p. 360). High-reliability organizations are characterized by their emphasis on avoiding errors rather than pursuing efficiencies, where remaining mindful to deviations from expected events is more important than developing efficient but mindless routines. Yet a perspective of collective mind also helps explain highly creative organizations, where the emphasis is on mindfully exploring novel solutions rather than mindlessly exploiting well-developed ones.

Collective mind resides in the mindful interrelations between individuals in a social system. One person's action or utterance, when considered by others, shapes theirs, which in turn (when heeded) shapes the next. This sequence of action and reaction resembles a set of exchanges in which one individual's creative output, once enacted, stands alone as a contribution and provides input to others' subsequent cognition and action. Yet a focus on the collective aspects of this interaction considers how one person's past thinking and action take on new meanings – to everyone involved – in the evolving context of subsequent thinking and action. In one scenario, for example, someone offers a "crazy" suggestion, like turning a shoe into an inflatable splint, that is dismissed and ultimately forgotten. In another, the same crazy suggestion is considered by others and built upon (using an IV bag in the shoe's upper half), ultimately leading to a creative solution. In the latter case, the same utterance takes on new meaning(s) through the mindful interactions of participants in the problem solving process. Farrell, in describing the close workings of the impressionists, for example, points out how "a chance idea that might have been discarded if the painter had been alone was supported by the group. Risky decisions were validated and the group began to develop its own subculture . . ." (Farrell, 1982, p. 459). The difference, in these situations, between having a good idea or a bad one (or none at all) depends on the nature of the social interactions with others.

By connecting across time, activities, and experiences, the full resources of the organization can be brought to bear on the solution of any one particular problem. Rather than relying on each individual's past experiences and expertise, collective creativity pools these experiences. Rather than relying on each individual's cognitive skills, collective creativity represents social interactions as a shared thinking process that spurs the search for novel interpretations of problematic situations and for novel solutions. Both what to think of and how to think of it become simultaneously the products of the social system and the contributions of individuals making up that system. A collective mind provides the organization with more ways to comprehend what is going on and more ways to respond.

A second way that analogical reasoning appears to differ at the group level from the aggregation of individual level reasoning is because, through the interaction of diverse individuals, it builds on itself in exploring new interpretations and distant analogies. Gian Zaccai, CEO of Design Continuum recognized this difference:

> You pick two people, with different experiences and maybe even different training and put them together and you've got that kind of a synergy, an exchange of ideas. Because whatever this person says will provoke a hundred different ideas in this other one and a hundred different memories.

Similarly, Nicole, an engineer at Design Continuum described how the brainstorms they regularly conduct produce unexpected ideas by pooling expertise and ideas from a variety of sources. In one meeting, designers were searching for solutions to a complex valve mechanism for a gardening application. Nicole recognized that a Water Pik toothbrush shared similar traits, which spurred another designer, Don, to explain how that product worked by using a "spring mast" valve mechanism. Nicole and Don, individually, may not have arrived at the potential value of a spring mast for solving the gardening project. But together, over a brief interchange, Nicole's initial suggestion prompted Don to recall past knowledge that had until then not seemed relevant. And even this connection emerged only after the prompting and new perspectives generated by previous analogies over the course of the meeting.

The interaction between Nicole and Don entailed more than an aggregation of two individuals listing potential problem definitions. One suggested frame shifts awareness in ways that make another visible. Fiske and Taylor (1991, p. 122) argued that "once cued, schemas [or frames] affect how quickly we perceive, what we notice, how we interpret what we notice, and what we perceive as similar and different." Further, research has shown that "a shift in schemas allows one to recall details not easily recalled from the other [original] perspective" (Fiske & Taylor, 1991, p. 125). One individual's introduction of an alternative frame makes salient different aspects of the situation which, in turn, prompt insights from the other participants into other potential frames. Such a process may occur at the individual level but group interactions increase the ability of its members to generate and shift between alternative frames of a given situation.

These group interactions reveal the central and social role that analogical reasoning plays in linking past knowledge to the demands of current projects, yet these interactions depend upon *how* knowledge is made available across the organization. Knowledge brokers engage in two activities that are intended to make the right knowledge available to the right people at the right time. First, all of the organizations studied had invested, sometimes heavily, in databases that codified the vast and valuable experiences of their members. IDEO and Design Continuum have shelves of project binders, intended to serve as records of past thinking and the solutions generated. McKinsey, Andersen, and Boeing have firm-wide databases into which people are expected to enter completed projects, including both lessons learned and abstracts of potential interest to others. Hewlett-Packard's SPaM group maintains a common server that holds all of the past models that were created, including documentation of different aspects of each program. The intention was to enable individuals to access the organization's past knowledge and, individually, to solve the problems they face in a current project. Yet as consistently as these organizations adopted such databases, their organizational members described their ineffectiveness. A Design Continuum engineer noted the failure of such a database:

> We had this library where different people were supposed to maintain different things. This person was going to maintain a library of glues, this one a library of plastic parts. And it just completely fell apart; It didn't go 2 weeks before it had completely fallen apart.

And one Hewlett-Packard informant related, "It's all in people's heads. The model's out there somewhere but there are so many models in the network drive that if you didn't know, you'd spend days trying to find out what you were looking for." Considerable investment has gone into capturing and codifying individual knowledge to make it available to others in the organization, yet these efforts were not valued by the very people they were intended to serve.

Rather than search through codified knowledge, the problem solvers of these knowledge brokering organizations rely on activities which enable them to recognize non-obvious connections between past problems and solutions and their current projects. An Andersen Consulting partner explained, "Everybody here has their own [network] in terms of just using voice mail and having your own set of personal contacts . . . I don't think anybody here actually peruses the Knowledge Exchange to get that type of information." From this perspective, we may see one answer to why technical knowledge management efforts often fall short of expectations. Formal databases codify knowledge, storing it in ways that could be easily retrieved using known and expected keywords. When problems are well known, these systems provide effective storage of the solutions that are typically associated with those problems. But the very efficiency of database "deposit-and-withdrawal mechanisms" makes them difficult tools for finding non-obvious links between ideas. As Picasso said, "computers are useless. They only give you answers."

Instead, individuals would often choose search activities that retain the equivocality of the organization's past knowledge, the multiple meanings that can be considered and re-applied in a new context. As one Hewlett-Packard engineer described,

> When you read about somebody's experience and then actually go and talk to them about it you find the level of knowledge is so much deeper than what can be transferred through a paper or an hour-long talk. There's a wealth of hidden knowledge that's a result of the struggles, the agonizing they went through to try to figure out what's the right way to proceed rather than the wrong way.

Informants described how they would attempt to tap the organization's knowledge through interactive communication with others. These search activities took the form of hallway conversations, brainstorms, and "tapping into personal networks." A McKinsey partner explained how these searches for equivocal knowledge unfolded:

> If I had a problem that was outside of my experience base I wouldn't know who to go to. What I would logically do is the most comfortable thing, which was to go to somebody who's in the practice and who I know from the office and say 'I'm running into some issues about IT cost production, how do you think about that? Who's the best person to call?' They would say 'Oh you really ought to talk to so and so.'

IDEO and Design Continuum rely heavily on brainstorming meetings (Sutton & Hargadon, 1996), and a Design Continuum engineer explained why:

> The reason to have collaboration and brainstorming is because you could invite a bunch of people and not know what they're going to bring from their experience and their kind of internalized data base and all that stuff.

By maintaining the multiple meanings of past knowledge, problem solvers maintain flexibility in creating new analogic connections between that past knowledge and current projects. This flexibility enables them to generate a range of alternative problem definitions to describe a particular situation and, from this range of problems and the solutions associated with each, the participants can consider and pursue ideas that might not have emerged otherwise. These linking activities combine existing ideas, and these new combinations represent the innovative "output" of the process of knowledge brokering. But much work remains before these innovative solutions become the working prototypes and final products they inspire.

### *Building New Networks Around Emerging Innovations*

The activities described by the steps of *Access*, *Bridging*, *Learning*, and *Linking* expose organizations to a range of potentially valuable ideas, bring those ideas into the organization, and help members reorganize them into valuable new combinations. *Building* describes the activities that individuals and teams use to construct new networks around those new combinations in order to ensure their success. Recognizing and creating novel recombinations of existing resources is rarely enough; innovations are successful only to the extent that they are adopted by and alter the behaviors of their intended audience. The expanding community that crystallizes around a new combination of resources creates the necessary conditions for turning initial innovations into enduring institutions, through diffusion (Rogers, 1995), learning-in-use (Rosenberg, 1982), and through the coordinated efforts, legitimacy, and social capital that such dense relationships provide to new ventures (Walker, Kogut & Shan, 1997). This adoption and subsequent evolution, from a network perspective, involves developing new ties to the expanding web of ideas, artifacts, and people that form an innovation.

The construction of new communities, industries, and institutions around emerging innovations has been well documented by institutional theorists. DiMaggio (1991, 1992) for example, described how Paul Sachs constructed the Museum of Modern Art despite resistance from the entrenched art museum community by bridging multiple academic and social worlds and building a new community from the resources pulled from those previously disparate domains. While Sachs' original advantage was as a broker between otherwise disconnected worlds, exploiting that advantage meant building redundant ties between those he alone previously bridged. Within processes of technological innovation, Garud and colleagues (Garud & Rappa, 1994; Garud & Karnoe, 2001; Garud, Jain & Kumaraswamy, 2002) have shown how communities form around emerging technologies, and how these communities play critical roles in the development of the shared meanings, goals, and standards that subsequently guide further development. Garud and Karnoe (2001) label this process "path creation," to reflect the necessary actions that precede path dependence. Martin and Eisenhardt (2001) found a similar network building process when they studied twelve internal development projects that spanned different divisions within large software organizations. While all projects began with the recognition of potentially valuable recombinations of their existing resources, the successful projects were those in which managers were able to build new networks around the emerging ideas – rather than attempt to bridge the boundaries between divisions shaped by the existing organizational structure.

Knowledge brokers are aware of this network-building process, and engage in activities that help to ensure that communities of users form around the new products and processes they develop. For example, Design Continuum's work on the Reebok Pump™ was successful in part because the firm was able to bring Reebok together with an existing manufacturer of IV bags. So while the project team at Design Continuum discovered a structural hole between the worlds of Reebok and IV Bags, their actions actually created redundant ties that, structurally speaking, eliminated their original brokerage position. And when Edison discovered potentially valuable new ways to use electricity and the electric motor, he founded companies dedicated to the exploitation of those particular innovations (and not to the further pursuit of new innovations): the Edison Domestic Telegraph Co (producing police and fire-alarm systems); the Edison Iron Ore Magnetic Milling Co., the Edison Speaking Phonograph Co., the Electric Light Co., the Lamp Manufacturing Co., and the Electric Railroad Co. (Conot, 1979).

In the development of the electric light, in particular, Edison's network building efforts can be seen. Indeed, in 1881, when he was preparing to introduce his new system, he publicly announced his intention to focus on building the business of electric lighting and away from inventing (Conot, 1979). From this point, McGuire, Granovetter and Schwartz (1993) trace the construction of an industry around Edison's system of electric lighting, describing how Edison and others built that community together from existing ideas, artifacts, and individuals. For example, and reminiscent of Selznick's (1949) study of the Tennessee Valley Authority (TVA), Edison early on attempted to co-opt the established gas interests by bringing them in as investors in his own venture. William Vanderbilt was one of Edison's largest investors and also the largest owner of natural gas stock in America, having bought Edison Electric Light Company stock as a hedge against this new technology (Freidel & Israel, 1986; McGuire, Granovetter & Schwartz, 1993). Edison also designed his system of electric lighting around the established understandings that consumers and regulators alike already held for gas lighting, making it easier for them to understand and interact with the new innovation (Hargadon & Douglas, 2001). He also drew in existing resources from more distant domains, hiring installers of burglar alarms, as the nearest skilled tradesmen, for installing his lighting systems. And when this profession proved too limited, he opened his own technical school in hopes of creating the necessary engineering community to support the new venture (Conot, 1979). His actions, while seemingly individual and entrepreneurial, were in many ways focused on bringing together many existing but disparate resources – building a new community – around his new venture of electric lighting.

IDEO managers are also aware of the need to build new communities around emerging innovations in order to ensure the survival of those ideas once they leave the safety of the project team. To do so, they often make sure to have division- and corporate-level executives involved in the development project, and thus committed to its success. They also recognize an additional role prototypes play in their client firms; as objects that are passed around and must not only speak for themselves but also attract the commitment of others. In one recent case, they constructed video scenarios of a new technology in use that was so successful it now appears on a client's website to draw in potential customers. Recently, IDEO managers have even begun to realize the value their brokerage position provides them in building new networks around other people's emerging ideas. In one case, they were approached by Eleksen, makers of smart materials, fabric which has conductors woven into it. Eleksen believed they had a potentially valuable technology with applications in many different domains. They did not, however, have the desire to develop a manufacturing and marketing apparatus necessary to make any of those ventures work. Instead, IDEO exploited their contacts across different worlds to build new connections between Eleksen and established organizations. In the first product to result from this endeavor, Logitech is manufacturing and marketing a protective case for PDAs that also unfolds into a fabric keyboard.

Taken together, the conditions and events that make up a model of the knowledge brokering process involve:

(1) the potential inherent in *recombinant innovations* that draw from existing ideas, artifacts, and individuals from across many *small worlds*;
(2) the *bridging* strategies that can expose organizations to the local resources of these different worlds;
(3) the *learning* activities that bring knowledge of these resources into organizations;
(4) the *linking* activities that recognize how knowledge, learned in one context, could be valuable in others; and
(5) the *building* activities that construct new networks around the emerging innovations.

## THE ORIGINS, SUPPORTS, AND OBSTACLES OF KNOWLEDGE BROKERING

The primary aim of this paper was to outline a grounded theory of knowledge brokering that links conceptions of organizational learning and innovation. This has left little room for discussion of how such organizations first establish their positions spanning multiple domains, how their internal activities find support in their culture and structure, and what impediments exist to innovation through knowledge brokering. These aspects of the process are important, however, in understanding the successes and problems in knowledge brokering.

### *The Origins of Knowledge Brokers*

While the research did not directly capture the origins of these knowledge brokering organizations, informants often discussed them. The evidence suggests these organizations did not explicitly seek brokerage positions within a larger network, nor did they dictate the internal behaviors that would support such a position. For example, IDEO began in the 1978 as Hovey-Kelley Design, a group of five engineers in Stanford University's Product Design program. Several Silicon Valley computer startups approached David Kelley (now CEO of IDEO) with projects because, while these firms had electrical engineers, they lacked expertise in mechanical engineering. As one of the original members recounted, "We were just staying one step ahead of the electrical engineers, who knew less about mechanical engineering than we did. But over time we've done thousands of designs. Now we know more than most." A senior McKinsey partner also described how only after they established a network position spanning multiple industries did they realize the value of combining their diverse experiences to help each client. Only then did they begin to recognize, support, and extend their linking activities. The roles of the in-house brokers – Hewlett-Packard's SPaM and Boeing's Ops Tech group – emerged through the foresight of founding individuals, who recognized the value of providing their services across a range of otherwise disconnected divisions and acquired the necessary resources to do so. As Corey Billington of SPaM described, "We came up with an analysis for our PC business that wrapped together a bunch of different things that had been trickling around. And it became a nice clean model that we then used to do a bunch of subsequent work with other divisions." Edison and Sperry capitalized on the emergence of electro-magnetics in the 1870s and 1880s, gaining their brokerage positions by diffusing such knowledge across industries. Hughes (1989) has described their strategy as solutions in search of new problems.

One trait appears common to each of these firms. Each began by exploiting a (relatively) small difference between their knowledge and the needs of others and, rather than build on their expertise within that domain, they chose to move elsewhere. In the production of new knowledge, these organizations pursued economies of scope rather than scale.

### *Structural and Cultural Supports for Knowledge Brokering*

The activities described as central to the knowledge brokering process require individuals and groups to pursue learning in new domains, to seek the knowledge of others, and to share their knowledge with others. While a complex web of cultural and structural factors support these actions, all firms shared one feature: the internal conditions of knowledge brokering firms reflected their external conditions. The knowledge brokering organizations studied had structures that mimicked the diverse and relatively disconnected domains of their environment, and a culture that rewarded the recombination of existing resources from across those domains. These conditions enabled and encouraged most members to act individually as knowledge brokers.

An organizational structure built around diverse projects replicates the multiple knowledge domains that these firms face in their environment. Further, the temporary and overlapping structure of project teams create the conditions for individuals to span multiple project domains and contribute by moving ideas from one to another. The organizational structure of these firms revolves around project teams. These teams form and disband according to project schedules, often pulling in additional members for brainstorms or short bursts of effort and rarely keeping the same members over multiple projects. They are often small, averaging from two to seven people, and changing in size over time depending on the demands of the project. The movement of people on and off projects allows teams to draw on the unique experiences of others as they are needed and allows those individuals with diverse knowledge to learn about and contribute to a variety of projects in a variety of industries. Further, individuals often belong to more than one project, if the demands of each are not enough to occupy them full time or if their particular skills are needed in others.

Also, teams are often composed of individuals working in multiple offices and locations rather than people in the same location. Because each team member's personal network typically includes those working nearby (Allen, 1977), drawing from multiple offices maximizes the range of outside resources that team members are aware of in the firm and can draw on. As a Boeing manager described, "Moving supervisors around is a good way of doing that so that a supervisor that was over here is now over there and can say 'Hey, we were working on that over there' and so then they can start to facilitate that communication."

The culture also creates the conditions for knowledge brokering at the individual level through norms and values that recognize an individual's diverse knowledge and reward his or her ability to apply that knowledge to other people's projects in a brokering role. Implicitly, these norms recognize that innovation involves recombining the existing ideas of others and not working alone to invent solutions. An engineer at Design Continuum explained, "People [here] get satisfaction sometimes because they think up really good solutions but also because they ferret them out from other people and put them together." A McKinsey partner was even more specific about the brokering role:

"Increasingly I think the route to success is by being able to bring unique solutions to your clients, not being the one to have the creative idea." At McKinsey and Andersen Consulting, for example, employees make partner based on the votes of their colleagues, whom they have worked with and helped, or not. A McKinsey partner explained, "If you're not contributing to the new ideas in the firm then you're not contributing to the fundamental value proposition and economics of the firm." The values inherent in contributing potentially useful solutions reflect the notion that everyone should be able to act as an individual knowledge broker and thus be able to provide innovative solutions when called upon to do so.

### *Impediments to Innovation Through Knowledge Brokering*

While this research focused on the conditions and actions that support knowledge brokering, it became apparent that these firms also face certain impediments to the process. Three barriers, in particular, appear significant: employee turnover and the loss of individually held knowledge, organizational size and the increasing difficulty of interpersonal communication, and the increasing demands for efficiency that threaten the uncertain returns of many learning and linking activities.

Employee turnover represents a significant threat to the diverse knowledge held by the knowledge brokering organization and yet, in some firms, turnover was considerable. There is a constant turnover of younger employees in the management consulting firms, whose business model is an "up-or-out" style of attrition (the ratio of associates to partners ranged from 5:1 to 7:1), yet the problem of turnover is not limited to the management consultants. Hewlett-Packard's SPaM group recognized the same threat. A manager explained how, "If somebody exits then a lot of that knowledge is lost. We actually have done real well in not losing people so we haven't had a big problem with that. But if we started to have a mass exodus we'd be in big trouble." Similarly, a Boeing manager described the problem of turnover, "It can be a problem to lose people. They're highly qualified, They've been here a long time, and the network sometimes collapses as you lose contacts and everything."

Several factors appear to mitigate the loss of individually-held knowledge through turnover, foremost among them, the "network" nature of these organizations. As the same Boeing manager later described, "Over time the network eventually resurfaces and people start to establish new relationships." Additionally, the constant sharing that occurs during brainstorms and other problem-solving sessions gradually diffuses much of the knowledge held by individuals throughout the organization. These social interactions are where individuals put forth their ideas and develop their reputations (Sutton & Hargadon, 1996). And while participants walk away with a better understanding of the problematic situation, they also gain a better understanding of other potentially relevant resources, and the people who know about them. The structural supports, and particularly the dynamic nature of teams further facilitates this diffusion of individually-held knowledge to others in the organization. Projects teams are continually built and rebuilt across otherwise persistent geographic and political boundaries within the organization, which foster the sharing of experiences between, for instance, a McKinsey consultant in the San Francisco office and one in Chicago, who are working together on a project in Indianapolis.

A second difficulty appears to emerge from increasing size. As these firms grow in response to their success, individual members find it increasingly difficult to tap the knowledge held by others. A SPaM manager and old-timer explained the problem:

> A lot of our practices were born out of the time when we were only 4 people and we could sit around a table and just talk about what we're doing for an hour. We would all pretty much know most of what we were doing. Now we're getting to be pretty widespread.

One interesting aspect of this dilemma is that it seems to occur in all of the firms studied, ranging in size from eight people to 48,000. At McKinsey, some remembered when it was easy to know what everyone else knew:

> Even with 150 partners, there was a reasonably good chance that I'd know 90% of them and probably what 80% of them were doing at any time. Now, with 4 times as many partners there's no way I'll know what my fellow partners are doing, let alone the remainder of the associate body.

As these firms increase in size, they face challenges in establishing new routines for sharing what they know. At Hewlett-Packard, this means growing beyond eight people, and the group's response is described by one of its members: "We're in that growth phase where we're not small, we're a little bigger than small and we're not well structured to deal with that." Many viewed this growth as a problem and responded with efforts to increase the efficiency of their knowledge sharing. One McKinsey partner described:

> There's a lot of ways we can be more efficient at disseminating information. But in the end it's still interpersonal connection and the challenge, as you get bigger, is how to maintain that while still taking advantage of what size brings you. McKinsey has gone from maybe not quite that small a number but where you know everybody to where we don't know everybody and can't. And we have to make that work.

These firms appeared to respond to their growth in ways that accepted, rather than resisted, the resulting internal fragmentation. As IDEO grew, for example, from 150 to 300 employees through the late 1990s, they responded not by increasing the amount of organization-wide interaction but rather by splitting into smaller studios. The intent was to maintain the close connections between individuals that fostered knowing what others know, and perhaps also the associated reputational effects that motivated and rewarded sharing knowledge. The studio exploited the relatively dense interactions that proximity produces (e.g. Allen, 1977), yet project teams were purposely constructed from across studios to bridge these otherwise disconnected subgroups. One result being that individuals could broker the knowledge of one studio in their interactions with others.

The final difficulty facing knowledge brokers is the pressure toward efficiency that results from perceived increases in the pace of work. Many informants talked about the sense of urgency under which they worked, and how that discouraged them from helping someone else with a problem or from taking the time to let others know what they had recently done. For example, in response to their growing size, Hewlett-Packard's SPaM group tried to institute a policy of presenting completed projects to inform everyone else in the group about what they had done. This policy, as one manager described, rarely led to actual presentations:

> We stipulated that people had to present to the rest of the group and it doesn't happen. Because we have no incentive, there's no reward. There's already another project. I'm on the next project, I'm busy as hell. Why schedule myself to give a presentation to the group?

The same pressures occur at Boeing's Ops Tech Center, where a manager complained, "The communication is sometimes a problem. People are so busy and it's so hard to stop your main tasks and think, okay, what thirty people do I need to go tell what I'm doing?" And at McKinsey, a partner described how time pressures affect people's willingness to help others, "They simply won't return your call, sometimes not even the first time. It depends a lot on the individual and how busy they are . . . you know our people are motivated to spend their time on their clients." Time pressure discourages individuals from engaging in activities that have vague or uncertain returns, yet those same activities appear to be central to the transformation of old knowledge into new innovations that routinely occurs in knowledge brokering firms.

The tendency to avoid the uncertain returns of exploring for alternative interpretations and actions appears to be mitigated, in part, by the structure of the reward systems. Because performance is often measured, formally and informally, by people's ability to help others and not by their performance on individual tasks, there remains a pressure to respond to inquiries, return phone calls, and attend brainstorms. So while time pressures increase, they are often offset by the pressure to perform in those social settings where such performance shapes reputations and rewards.

## DISCUSSION

The perspective of innovation as the recombination of existing ideas, and the opportunity to view such a process within knowledge brokering firms, suggests several alternative perspectives on the innovation process and directions for future research that have not been previously considered.

The conditions that enable knowledge brokering depend on the ability of some individuals and firms to see possibilities that others do not or cannot see for themselves. Often, knowledge brokering firms combined ideas that clients had seen before but did not consider useful or relevant – for example, the use of a supersoaker in an emergency room tool. Such occurrences suggest the difficulty of recognizing when knowledge in one domain is useful elsewhere requires more than simply a structural explanation. This difficulty derives from the contextual, domain-specific nature of knowledge and the inability of domain inhabitants to recognize when "irrelevant" knowledge can become relevant. The activities of knowledge brokering organizations suggest that roles and identities may be a strong influence on the abilities of individuals and organizations to convert their past knowledge into new innovations. By viewing domain boundaries as manifestations of the habitualized actions and beliefs of inhabitants, inhabitance itself becomes a role that perpetuates an organization's network position. Knowledge brokers, by not identifying with any one domain, may be more able to resist the "dogma" of any one domain and recognize connections that more centrally focused inhabitants might not. Research into how these different roles mediate the innovation process may provide insights into how, when faced with the same information, some are able to see connections where others cannot.

The actions of individuals and groups that share past knowledge, held by one participant and potentially useful to others, reveal social aspects of the creative process that are neglected by research on individual creativity and on group problem solving. The adoption of frames to interpret problematic situations appears to be a central part of the problem solving process in knowledge brokering organizations. The diversity of situations to which the members of these organizations are exposed requires them to define each problem-solving situation anew and creates the opportunity to do so by providing a range of past definitions to choose from. This framing activity reveals both the role of problem *setting* in organizational problem solving and the influence of group interactions on the problem setting process. The flexibility of defining situations in ways that inhabitants of a domain traditionally have not, the diversity of "frames" that each participant possesses, and the interactions that encourage creative applications of these different frames all may play a large role in group creative efforts. Research on creative problem-solving at the individual and group levels may benefit from considerations of problem-setting and frame experimentation, which appear central to the organizational processes described here.

A model of knowledge brokering also provides a counterpoint to more structural approaches to social network theory. While innovation takes place within social structures that can be mapped, more or less accurately, as social networks; the map is not the territory. As Salancik (1995) reminds us, networks come into being when individuals and organizations interact, and not the other way around. The network theoretic features that separate domains from the larger social world reflect more than cause the fragmented landscape. The dense ties within and sparse ties across domains result from the tendencies of inhabitants in any one domain to overlook the value of resources that, while physically nearby, derive their meaning and value only from the vantage points of other domains. Network perspectives are useful for *describing* small worlds but not for *understanding* the underlying cognitive and behavioral mechanisms that create and perpetuate these worlds.

Additionally, network perspectives run the risk of presenting as static an innovation process that commands attention for its dynamism. Burt (2000) distinguishes between dense networks, where social capital resides in building redundant ties, and sparse networks, where social capital resides in bridging non-redundant ties. For network theories to adequately address the dynamics of innovation, however, more attention should go to those moments when dramatic and global shifts in network structure come about – what physicists describe as phase transitions – as a result of adding or subtracting a few local ties. As DiMaggio (1997, p. 280) suggests, the challenge is "to understand the cognitive aspects of major collective events in which large number of persons rapidly adopt orientations that might have appeared culturally alien to the majority of them a short time before." When Elvis linked a white teen audience to the large but untapped resources of the rythm and blues community, when Edison successfully commercialized the electric light, or perhaps when (despite the Alto, the Altair, and the Apple II) Microsoft invented the personal computer. Returning to Salancik (1995, p. 349), "A network theory that accounts for the appearance and disappearance of structural holes – rather than how they can be used to advantage – and the consequent changes in interactions over time may provide us with a better understanding of how collective action is organized."

Finally, the value of a model of knowledge brokering lies in how well this resembles innovation processes in other settings, or is idiosyncratic to the firms studied. While in most firms innovation is infrequent and elusive, the central task of knowledge brokers is to routinely generate innovative solutions to novel problems. In this way, these organizations offer a glimpse into an innovation process that may occur yet remain hidden in other firms. Similarly, the perspective of innovation as knowledge brokering may offer insights into how such infrequent innovations could be facilitated that would not emerge from more traditional models of learning or innovation. For example, by grounding an organization's internal innovation practices in its relation to the environment, this perspective suggests that hiring creative people and building creative cultures may not be sufficient. Providing organizational members with broad exposure to a variety of domains, and with flexibility in choosing the problem definitions they work on, may also be necessary to increase their ability to generate novel insights and recombinations. Also, efforts to increase the social interactions between otherwise isolated divisions and work groups may be more effective than efforts to capture and codify knowledge in centralized databases – particularly when those efforts are reinforced by a structure and culture that rewards individuals for acting like knowledge brokers within the organization.

A model of knowledge brokering also has implications for how organizations might develop their own more explicit knowledge brokering capabilities. For example, large multidivisional firms may be better able to exploit their broad range of diverse activities by establishing internal brokering units whose central task is to recognize and recombine useful ideas. Informants in Boeing's Operations Technology Group and Hewlett-Packard's SpaM Group, for instance, described how their groups' usefulness derived in large part from the inability and unwillingness of managers to share ideas across often competing divisions. Further, by creating a separate unit that values recombination over invention of new ideas or the exploitation of existing ones, these brokering units may develop the necessary structural and cultural supports for the knowledge brokering process. Smaller firms may model themselves after knowledge brokering firms – either in the form of consulting firms that position themselves in a wide range of industries and provide mainly innovative solutions, or in the form of the more entrepreneurial consultants like Edison and Sperry, whose consulting work brought them into contact with many industries in which they later developed products for themselves. The cases of Edison and Sperry are particularly useful in mapping out potential knowledge brokering strategies to exploit the recently and rapidly evolving information, bio-tech, and internet technologies. As these technologies diffuse into other applications and markets, those firms that know these technologies but are also capable of rapidly learning the existing problems and solutions of new markets may be well-positioned to recombine these diverse ideas.

## CONCLUSION

The model of innovation through knowledge brokering preserves the central roles of both organizational learning and innovation, yet shifts attention to the relationship between these concepts and how both are grounded in the concrete realities of their surrounding social structure. It does so by offering a glimpse into how people in organizations recognize when the knowledge they and others learned elsewhere can be used to generate innovative solutions in new contexts. This model does so by explicating the innovative potential inherent in recombining existing ideas from other domains, and by explaining the cognitive and social processes of problem solvers that must regularly recognize and exploit that potential. This process can appear as simple as recombining ideas that already existed elsewhere, but it is not. All too often, solutions to a problem lie close by, but are obscured by the different context in which they were learned and, in organizations, by the different people who learned them. For innovation, it's not what organizations already know that is important. It's how they use what they know to make sense of new situations and how they use new situations to make new sense of what they already know.

## NOTE

1. The small world phenomenon derives from graph theoretical definitions of systems that are loosely coupled domains of dense interrelations (Simon, 1961). The use of the term small worlds to describe the individual domains, however, is intended to reflect how such small world networks are experienced by their inhabitants, most of whom lack the larger perspective of network theoreticians.

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