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Pratim Datta
Washington State University

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An Agent-Mediated Knowledge-in-Motion Model

Pratim Datta
Washington State University
datta.pratim@gmail.com

Abstract:

With millions invested in knowledge management (KM), researchers and organizations are constantly investigating how firms can best organize their KM processes to reap instrumental benefits. Yet, most KM research, apart from being fragmented, overemphasizes knowledge creation and draws little attention to key intermediaries in the KM process. The paper captures the specificity of agents as key players binding knowledge creation and knowledge application. Specifically, the paper introduces a conceptual process model that views knowledge management as an agent-mediated series of knowledge transformations, envisioned as the agent-mediated knowledge-in-motion model. The proposed agent-mediated knowledge-in-motion (KiM) model embodies the cycle of knowledge creation and reuse. By tying agent-based research to knowledge creation and application, the paper describes how organizations can strategically employ human and software agents to enhance the creation, transfer, application, and dissemination of knowledge. In the process, the paper highlights specific roles and attributes of various agents in the KM process. Using the organization as the primary unit of analysis, the scope of the discussion surrounds the conceptualization of an agent-mediated knowledge management process where data is transformed into information, information to knowledge, knowledge to creativity, creativity to innovation, and finally, the diffusion of innovation into data- thus tying together a cycle of knowledge transitions from creation to reuse.

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1. Introduction

Knowledge has long been a key resource of the post-industrial world, and, like other resources, knowledge, too, requires management and organization. In discourses on knowledge management (KM), the fact that the prosperity of firms hinges on their ability to identify, mobilize, and apply knowledge for economic returns is well-argued (Stewart 1997; Eisenhardt and Martin 2000; Gupta and Govindarajan 2000). Yet, the question of how organizations can create and apply knowledge for economic returns remains a contentious topic often mired in anecdotes. As organizations invest millions of dollars in an apparent bid to "systematize, enhance, and expedite large-scale intra- and inter-firm knowledge" (Alavi and Leidner 2001: 108), it is imperative that they also gain a systematic understanding of the key pieces (i.e., key processes and players) of the knowledge management puzzle (Davenport et al. 1998). Lacking an understanding of key processes and players in KM, ongoing and future KM efforts will likely end up as ambiguous investments with little economic or instrumental benefits. As Davenport et al. (1998) comment, a failure to garner returns from KM investments can lead to an early demise of KM initiatives, leaving a bitter aftertaste. So acute is the issue that, in order to maintain executive sponsorship, it is now mandatory for firms such as Chevron and Mitre to document the process by which KM initiatives create and apply knowledge for economic returns (Turban et al. 2001).

Even though research and practice unequivocally confirm that successful KM efforts must create, transform, and apply knowledge to provide instrumental benefits, the knowledge transformation puzzle remains far from transparent. In particular, there is a demonstrable lack of effort in explicating how agents in knowledge management are central to reengineering the KM process from knowledge creation to knowledge application (Von Krogh et al. 2000), helping reestablish knowledge as an economically viable resource rather than an elusive asset. While existing research (e.g. Nonaka and Takeuchi 1995; Alavi and Leidner 2001) has attempted to answer ***why*** knowledge must be created and applied, explicating ***how*** knowledge is transformed from creation to application and ***who*** influences these transformations has received little scrutiny. In unraveling ***how*** knowledge transforms and ***who*** drives the transformations, this paper reconsiders knowledge management as an agent-driven process where knowledge management agents, as key players, streamline the transformation of knowledge from creation to application.

In an attempt to couple agent roles with the process of knowledge creation and knowledge application, the paper defines knowledge management as ***a series of agent-mediated processes*** governing the ***creation, transformation, utilization, and dissemination*** of knowledge. Central to our discussion is the following inquiry: ***How do agents facilitate knowledge transformations from knowledge creation to knowledge application?***

The objectives of this paper are threefold. First, to explicate a KM process that links knowledge creation and application; second, to explore the conditions and contingencies that facilitate KM; and third, to put forward a theory-driven framework called the "Knowledge-in-Motion" (KiM) model that captures the workings of the agent-mediated KM process that links knowledge creation to knowledge application. The goal is to advance an agent-mediated knowledge management model that captures and links the aspects of knowledge creation and knowledge application. Specifically, the paper forwards a conceptual process model by linking different knowledge management agents to corresponding phases of knowledge transformations. The scope of the proposed model is bound by a series of knowledge management processes that describe how various agents contribute toward streamlining knowledge transformations, i.e., data to information, information to knowledge, knowledge to creativity, creativity to innovation, and finally, the diffusion of innovation into data. It is an agent-driven cycle of knowledge creation, use, and reuse.

This paper advances existing research on knowledge management by specifically addressing how organizations can use agents to create, manipulate, apply, and disseminate knowledge toward

simultaneous appropriation and sharing of data and knowledge. In doing so, we develop a typology to delineate different agents involved in the KM process. We also clarify specific roles and attributes central to the functioning of different types of agents, suggesting how various agents can bridge rigid knowledge boundaries that inhibit transformations. The theoretical model developed in this paper potentially serves as a conceptual roadmap to assist researchers and practitioners in gathering a better and systematic understanding of how organizations can strategically use agents to create and apply knowledge for sustained economic and competitive advantages.

The paper is organized as follows: Section 2 begins with an overview of theoretical traditions on agents as brokers in KM processes. The section discusses how software and human agents are crucial in smoothing knowledge state transitions as knowledge undergoes change in context, interpretation, and use. Section 3 develops a theoretical framework that conceptualizes and recasts KM as a cycle consisting of agent-mediated episodes linking knowledge creation and knowledge application. Here, I develop the agent-mediated KiM model and explain it as a cyclical process of five discrete agent-mediated knowledge transformation episodes. Therein, I sketch agent [meta] characteristics and roles corresponding with ad-hoc KM agent classifications. Section 4 concludes with a discussion of the contributions of the proposed KiM model and offers future research directions.

2. Theoretical Background

2.1 Agents and Knowledge Management Research

Knowledge management cannot occur in a vacuum but must draw upon a portfolio of agents. Agents are relatively autonomous entities that perform intermediation tasks on behalf of an organization. In the context of KM, agents are either software artifacts (embedded algorithms that perform autonomous functions on behalf of the user such as Boland et al.'s "Spider") or human entities (autonomous people or groups performing prescribed intermediation activities such as Nonaka and Takeuchi's "knowledge-creating crew") embedded in organizational knowledge flows.

Agents in knowledge management are key players comprised of knowledge workers and technologies that connect, transform, and translate knowledge (Nonaka and Takeuchi 1995). Agents in knowledge management catalyze changes in the KM process by creating an ambience of sharing and mentorship (Van Krogh et al. 2000). They play a pivotal role in KM by identifying and collectively leveraging distributed and diverse sources of knowledge, thus actualizing an extended field for distributed communication and interaction (Alavi and Leidner 2001). For example, in a study of electronic document dissemination, Hansen and Haas (2001) traced the role of agents such as practice groups and marketing departments in gathering, selecting, editing, codifying, and publishing knowledge within the firm, therefore facilitating knowledge exchange and creating internal knowledge markets to match intra-organizational microeconomics of supply and demand. The gist of this discussion is that it is important to acknowledge that the fragility of knowledge must be supported by agents who, as brokers of change, trigger, interface, convert, and facilitate KM (Nonaka and Takeuchi 1995). Responding to the relative silence in mainstream IS research on the description of roles and practices of agents as brokers in knowledge management (Pawlowski and Robey 2004), the following sub-section draws upon pivotal concepts from organizational theory research to clarify the activity of brokering and the importance of agents as brokers in organizational knowledge management.

Agents as Brokers in Social Networks

Rooted in the social network perspective, knowledge brokering describes activities that allow knowledge transfers by creating ties across knowledge clusters internal and external to the organization. Partly because intra-group knowledge is redundant, organizational members rely on social networks of production (Burt 2000).

The substance of Burt's (1992) argument is that functional clusters impede knowledge sharing and transfers because they tend to lack diversity of knowledge and information. Too specialized and routine in their orientation, these functional clusters often find themselves disassociated from others, thus creating a structural disconnect that Burt (1992) calls structural holes. Bridging structural holes requires the presence of agents. Agents span structural holes across organizational boundaries to offer information access and to

control privileges (ibid). These agents perform brokerage functions by virtue of being "rich in the social capital of information and control benefits associated with relations that bridge structural holes" (Burt 2000: 124). In short, information arbitrage from the presence of structural holes becomes the brokers' advantage. The appropriateness of using agents as weak ties to bridge structural holes in organizational knowledge management stems from a utilitarian perspective of knowledge. The utilitarian perspective allows us to highlight the variety of roles and attributes helpful in identifying role references for agents in knowledge management—from access to action.

The structural hole metaphor builds on Granovetter's (1973) argument of the "strength of weak ties." A weak tie bridges structural holes to accelerate the sharing and transfer of knowledge (Burt 1992). In social networks, functional clusters are reminiscent of strong ties that relay redundant information because the same information circulates across the network. However, as Granovetter (1973) maintains, weak ties enhance knowledge transfers by linking previously disconnected knowledge clusters for information access and flow. While agents with strong ties do offer trust and group cohesion benefits, they capitalize on information reinforcement and redundancy (Burt 2000). It is only with the introduction of agents as weak ties that agents reduce redundancies in information and knowledge transfers by crossing functional and practice-oriented boundaries (Ibid). Thus, weakly tied agents provide opportunities for knowledge transfers by bridging different functional clusters, each marked by their strong *intra-group* but weak *inter-group* ties.

As I remarked earlier, while agents sometimes use strong ties for building intra-group trust, they use their weak ties to create social capital by offering information benefits that are additive rather than redundant (Burt 1992)—benefits that are particularly instrumental under conditions of uncertainty and complexity associated with managing knowledge (Hansen 1999; Alavi and Tiwana 2002). In short, the strength of weak ties arises from agents acting as brokers that link knowledge clusters by means of interfacing, translating, and controlling knowledge transformations. By doing so, agents establish a shared context through peripheral participation (Brown and Duguid 1991).

While Burt and Granovetter focus on the structural network, Wenger's (1998) work on communities of practice offers further theoretical guidance on how peripheral participation and interaction allows for effective sharing and transformation of knowledge. Instead of demarcating clusters defined by functional boundaries, Wenger uses the notion of "communities of practice" to demarcate clusters bound by practice (e.g. special interest groups) rather than by function. Embedded in a pragmatist perspective that defines knowledge by social context (Pawlowski and Robey 2004), communities of practice reinforce notions of strong tie clusters captive to their own worldviews, once again creating structural holes. Sharing knowledge across communities of practice requires the presence of a weak tie, thus allowing for knowledge brokering opportunities through peripheral participation and boundary spanning (Katz and Kahn 1978).

According to Wenger (1998), brokers are entities that effectively connect, coordinate, and transform knowledge across distinct boundaries or knowledge states. "The job of brokering is complex. It involves the processes of translation, coordination, and alignment between perspectives. It requires enough legitimacy to influence the development of a practice, mobilize attention, and address conflicting interests. It also requires the ability to link practices by facilitating transactions between them, and to cause learning by introducing into a practice elements of another" (Wenger 1998: 109). As brokers, agents provide multiple value-added services. First, brokering allows agents to create a shared and stable syntax to ensure reliable communication between sources and destinations in KM, thus establishing a common language of reference as a template for KM activities (Shannon and Weaver 1949). Second, in order to align syntactic interpretations, agents broker across Dougherty's (1992) "thought worlds" (Dougherty 1992) to align different styles of thinking and disparate understandings. Third, agents broker across multiple clusters of specialization and practice to transform interpretations through innovation and its diffusion, therefore making the organization's localized and embedded "knowledge stock" actionable (Choo 1998).

2.2. Software and Human Agents in Knowledge Management

Whether agents in knowledge management are software or human is often a function of their underlying characteristics and roles in specific phases of knowledge transformation. Both software and human agents

play crucial roles. For example, software agents can embody complex functions that scan, collect, and structure data into visual depictions (e.g. cross tabs, pivot tables, plots) without requiring the user to learn the complex algorithms used in translation. Similarly, human agents (e.g. interpreters) allow speakers to make extempore speeches in their own language without having to worry about the complexities of translation. Armed with unique attributes, software and human KM agents, in unison, orchestrate the organization and management of knowledge by alleviating inherent translation and conversion complexities.

Software Agents

The growing popularity of web and object services (e.g. CORBA, DCOM), portable Java code, and component integration architectures (e.g. OpenDoc, ActiveX) has, to a certain degree, simplified software-based translation and communication across multiple data sets and applications. Moreover, advances such as object-oriented programming have allowed for the embedding of organizational data and processes into routines, repositories, and functions to realize opportunities for time-saving, reducing duplication of effort and maintaining overall consistency through rule-based reasoning. Because of their parsing capabilities, software agents have the ability to handle complexities related to accessing multilevel data hierarchies, optimizing return values, and analyzing multiple sources and threads. Software agents can easily handle volume and complexity and are particularly efficient in the face of structure and routine, providing a consistent and standardized logic for iterations. While it is true that software agents are too rigid to capture subtle nuances surrounding knowledge transformations, they are exceptionally robust in tracing minute objective changes that are likely to go unnoticed by human agents. For example, software agents are often used to map marginal shifts in stock prices and exchange rate fluctuations, allowing them to react (e.g. limit order buy/sell) in an extremely short time period. Human agents are likely to find it more difficult to map such infinitesimal shifts and respond immediately.

Software agents, however robust and consistent, suffer from limitations. Software agent constraints relate to limitations of syntax and pre-specified parameters (however erroneous) that often fail to capture the overarching domain of application and understanding. Because a software agent uses a predefined and objective response logic, the outcome may be efficient, yet sub-optimal. For example, in software compilation, a debugger can easily identify syntax errors that the keenest human eyes would miss but fail to identify even the simplest of logic errors. Similarly, a search engine (as an agent) can efficiently parse through millions of documents but will return values solely based on keywords rather than relevance. In short, software agent logic is *constrained by its objective syntax and parameters*. A software agent, therefore, offers the greatest instrumental benefit in knowledge transformations that emphasize objective criteria, procedures, and standards.

Human Agents

For knowledge transformations requiring translation and reinterpretation, the standardized logic embedded in software agents, however comprehensive, fails to deliver (D'Adderio 2003), thus necessitating the use of human agents. Human agents, unlike software agents, are more suited to handling complexity, assisting in the creation and rebuilding of shared meaning, and reinterpreting retroactive knowledge to restore meaning in relation to a new context (Spender 1995; Kogut and Zander 1992; D'Addrerio 2003).

Human agents, by virtue of their social and functional ties across organizational and social networks, have the ability to establish a common identity across sites (Star and Griesemer 1998). A study of general managers by Kotter (1982) revealed that managers who knew and linked multiple groups together to implement policy offered the greatest information benefits for the organization. Bartel and Garud (2002) established how consultants, as human knowledge agents, used their diversity of knowledge and connections to enable knowledge interactions among heterogeneous firms. Similarly, Fleming (2002) illustrated how Hewlett Packard's strategy of moving engineers across projects resulted in newfound creativity because engineers, as agents, created weak ties across functions and communities of practice. Recently, Pawlowski and Robey (2004) revealed how IT professionals broker both IT and business knowledge across organizational boundaries through surfacing and challenging the assumptions behind proposed processes and translating and interpreting across business units. These are practices instrumental in the transfer of knowledge. Human agents, therefore, by virtue of singular characteristics that separate them from software agents, are more constructive for knowledge transformations that rely on creating

new meanings, linguistic routines, and shared understandings (Boland and Tenkasi 1995; Pawlowski and Robey 2004). Thus, the general demarcation scheme assumes that while human agents in knowledge management seem to be resilient in the face of subjective criteria, software agents are resilient in the face of the objective criteria.

Organizations will choose agents because of their specific attributes, independent of whether agents are software or human. Organizational choices surrounding the allocation and deployment of different human and software agents, therefore, need to correspond with episodic knowledge transition requirements. Certain agent attributes facilitate certain phases of knowledge transition but lack immediate value for other phases. Therefore, organizations must rely on the collective attributes of software and human agents to organize and transform knowledge within and beyond organizational boundaries. The forthcoming discussion underscores how different software and human agents in every phase of knowledge transformation have distinct responsibilities– consistent with specific attributes that define their roles across various aspects of knowledge transformations.

3. FRAMEWORK DEVELOPMENT: THE AGENT MEDIATED KNOWLEDGE-IN-MOTION MODEL

The agent mediated KiM model introduced in this paper consists of two major activities, each comprising distinct episodes. The activities are "knowledge creation" (Activity A) and "knowledge application" (Activity B). Knowledge creation focuses on employing a set of agents for the exploration and extraction of data and information to create and assimilate knowledge for creative venturing. In complement, knowledge application focuses on employing another set of agents for the exploitation of knowledge into creativity and innovations and their subsequent diffusion for appropriation and reuse. Exploration and exploitation of knowledge complement one another: "An organization that engages only in exploitation will improve its knowledge in an increasingly obsolescent technology or strategy. An organization that engages only in exploration will never gain any return from its discoveries" (p. 37, March 1991)
Knowledge creation involves two distinct episodes: (i) the acquisition and standardization of information from data and (ii) the creation and codification of knowledge. Information acquisition begins by using information agents to filter vast amounts of data into information. The episode emphasizes the use of agents to retrieve and reorganize data using a common syntax such as a standard reporting format so that the information generated is immediately usable by the organization. The information is used, thereon, to create knowledge. Creation and codification of knowledge begin as knowledge agents extract non-redundant information and convert tacit knowledge into explicit knowledge.

Knowledge application involves three distinct episodes: (i) the promotion and synthesis of creativity from knowledge, (ii) the transformation of creative ideas into innovation, and (iii) the diffusion of innovations as data and knowledge. Creativity agents spur creativity from knowledge and synthesize creative ideas. Innovation agents transform creative ideas into innovation by pushing feasible concepts into the innovation pipeline as product or process advances. Finally, during innovation diffusion, diffusion agents separate sensitive and non-sensitive information from resulting innovations: diffusion agents recirculate sensitive data and knowledge within the organization while making non-sensitive innovation data publicly available as information in commercial products and publications. Throughout the activities and episodes of the KiM model, the deployment of various agents is a function of exclusive agent roles and attributes that coincide with specific knowledge transformation activities. Figure 1 summarizes the overall agent mediated KiM model.

3.1. Activity A: Knowledge Creation

Episode 1. Information Acquisition

Information acquisition is the process by which data is transformed into information. Growth of digital networks along with advances in machine intelligence, data-storage capacity, and high-throughput data-acquisition systems have dramatically reduced the cost per data point, leading to cheaper and easier access to vast repositories of raw data (Masi 2000). However, only a fraction of this raw data is relevant for a firm. The challenge lies in transforming raw data into information. Because the heterogeneity of raw data makes it difficult to store it in all possible anticipated forms, it is imperative to convert data into information for the sake of relevance.

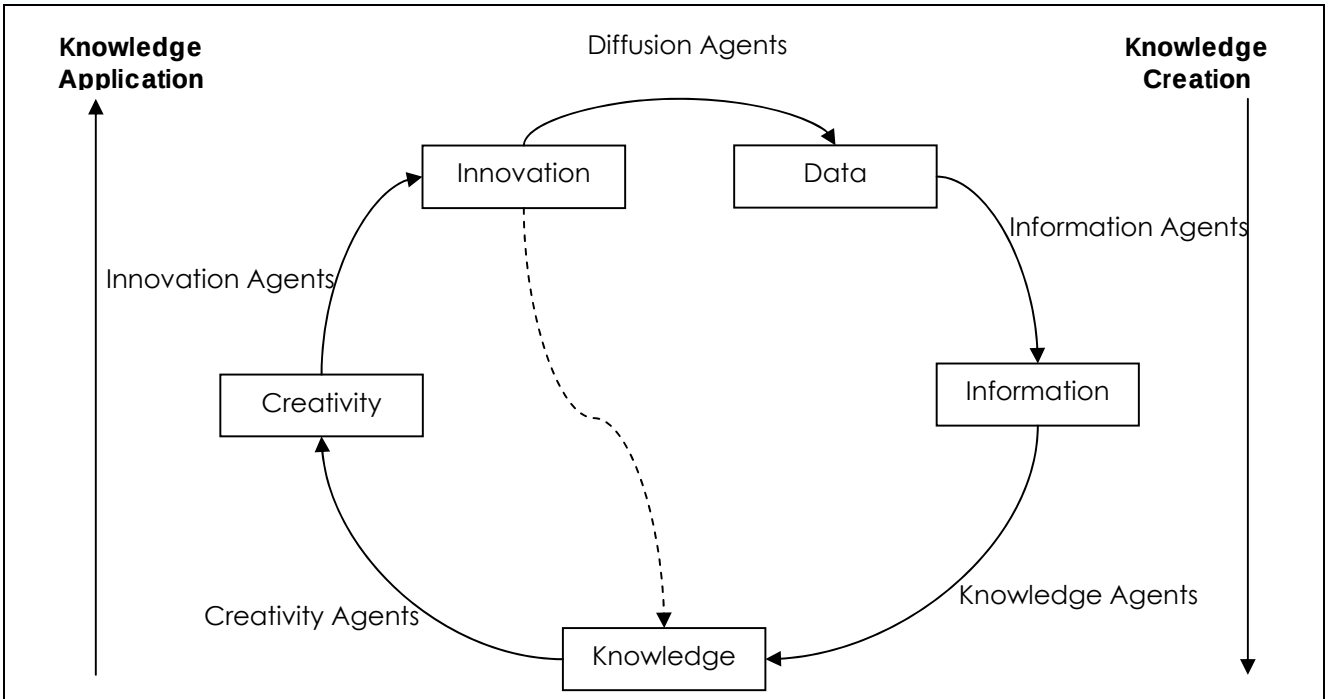

Figure 1: The Agent Mediated KiM model

Zack (1999) defines data as observations or facts lacking context and are therefore meaningless; information results only when data is placed within a meaningful context. Information, therefore, is timely, structured, and relevant data. Timely because information is time sensitive; structured because information must be provided in a shared format and relevant because information must be usable in the organizational context.

This episode transforms data into information by moving from the generic to the specific by increasing relevance. In this episode, firms use various search mechanisms to query and retrieve data and filter them based on contextual relevance; irrelevant data is treated as "noise." Firms initiate noise reduction strategies using effective data filtering, structuring, and standardization techniques that can transform a "mountain of data into useful information" (Masi 2000). By filtering raw data into timely, structured, and relevant information, firms add value by "informating" (Zuboff 1988): a process by which dispersed data is transformed into specific information for a "potentially more penetrating, comprehensive and insightful grasp of the business" (p. 212, Zuboff 1988). For example, organizations constantly query product parts data from supplier databases and extract only requisite and updated parts data. The parts data is then transformed to a common organizational structure using organization-specific identifiers and descriptions. The result is the populating of organizational databases and data warehouses with information that follows a common schema or structure that is well understood within the organizational context. As a result, at this KM boundary, transformation of data into information is driven by a sense of achieving common structure and context.

The significance of this episode in the KiM model lies in its situatedness as a gateway to the distributed and vast repository of digitized data repositories across digital networks. Conversion of data from its native distributed and raw state into information is not an easy task. Transcoding or information agents assist in this transformation (Ihde et al. 2001). Because data restructuring and transformation can be achieved by routine functions, filters, and queries, information agents in this episode of transformation are software-based (human intervention only exists in the designation of links and inscription of logic). Information agents are, therefore, modules comprising query algorithms and logical filters to routinely access, filter, aggregate, analyze, and transform data into information.

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Information agents operate at the frontlines of a knowledge management process, playing the role of scouts. This involves scanning the environment for data that can add value to organizational goals (Ancona and Caldwell 1992). At the user interface, information agents, as scouts, use technologies such as document frameworks, distributed objects and services, databases, messaging, and workflow tools to scan (e.g. search/ query, filter, load) the environment (e.g. other servers, application data) for relevant data (Bradshaw, et al. 2004). The relevant data is then restructured and formatted based on organizational specifications (e.g. standards). An interesting analogy may be drawn by referencing to the use of syndicated feeds using RSS and ATOM. Syndicated feeds use software agent-based technology to scout the environment for relevant data in order to extract and restructure it using the browser's presentation (or possibly the user's customization) logic.

Fulfilling the role of scouts in seeking and transforming data into information requires that information agents possess certain attributes. First, given the growing heterogeneity of data sources that information agents need to scan, filter, and transform, information agents need to be highly modular (Wenger 1998). Second, information agents need to be able to standardize information to restructure extracted data as per organizational specifications (Wenger 1998). Modularity refers to how different software modules (or their combinations), as instantiations of information agents, can be used to scout, extract, and restructure data into information. Organizations can program different information agents with different instructions to interface with heterogeneous data networks and other data services. An organization can initiate one type of information agent to scout for suppliers in order of their prices and use another type of agent to organize suppliers by transaction history. Modular functions are easy to inscribe in software agents and remain an important property for information agents that require different logic structures and communication interlingua to interface with heterogeneous data sources. As such, object-driven development, APIs (application programming interfaces), and agent construction technologies (e.g. CORBA, ActiveX) have greatly enhanced software agent modularity, allowing for interactions with a variety of local and remote applications and databases and the employment of modular multi-agent systems (Fayyad and Uthurusamy 2002).

Standardization refers to an information agent's ability to extract relevant data, restructure data into information, and load the information to be on par with preset organizational pre-specifications or standards to maintain syntactic consistency, which aids referencing and indexing for assimilation. Standardization is an elemental noise reduction strategy because it allows the restructuring and loading of content using specific syntactic frames of reference. Moreover, developments in the communication interlingua (e.g. xml) in information agents today offer an increased level of standardization. For example, supplier search bots, information agents, are modularly developed and deployed to periodically scout and extract specific data such as supplier price points and currency exchange rates from various distributed sources and formats (e.g. xml files, application data, public and proprietary databases). Subsequent to extraction, queried price quotes in one type of currency (e.g. Euro, Yen) require standardization into a pre-specified format (e.g. U.S. dollar with two decimal places). Thus, the information agent's ability to standardize data into information for assimilation is vital to this episode of knowledge transformation.

> *Proposition 1: As scouts in the transformation of data to information, software information agents that are capable of modularity and standardization will contribute to higher levels of information acquisition and assimilation than human information agents will.*

Episode 2. Knowledge Creation

Having acquired information from data, information needs to be transformed into knowledge. According to Stohr & Zhao (1998), "Knowledge is the capacity to turn information into profitable action. Information, on the other hand, is data rearranged, sorted and aggregated so that it becomes suitable for input to a knowledge processor of some kind." Knowledge is different from data and information: it evolves from them. Because knowledge is broader, deeper, and richer than data or information (Davenport and Prusak 1998), "extracting information from data and converting this information into effective business knowledge is a key to business survival" (Schimmoller 2001: 13).

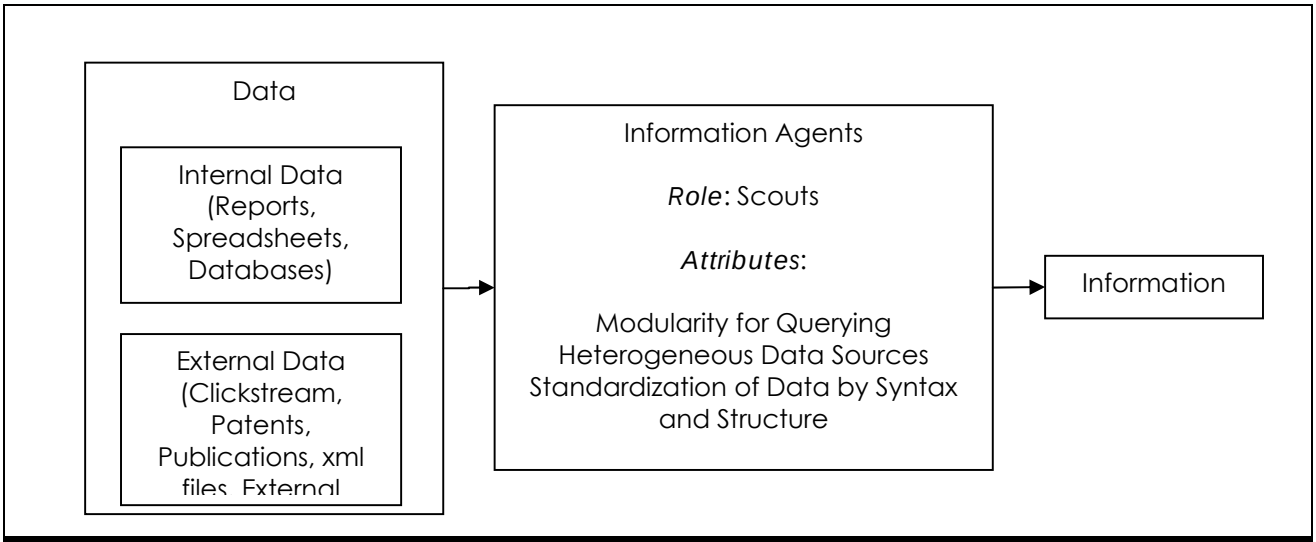

Figure 2: Information Acquisition

The knowledge creation episode deals with the contextualization of information to create knowledge. This episode of the KiM model rests on assigning organizational meaning to the available information stored by information agents as structured content (e.g., in data warehouses). Because of the tremendous modularity of information agents, considerable information is generated that, though standardized, is sometimes redundant and, therefore, non-value added. The revelation of fresh and meaningful content from information is what creates knowledge (Turban et al. 2001). Abstract, unapplied information, therefore, requires transformation into knowledge in order for it to contribute to the achievement of organizational objectives. As a result, the process of contextualization seeks out non-redundant, specific, and value-added information that is meaningful, actionable, and fresh to the organizational context.

Organizational knowledge is both tacit and explicit. Tacit knowledge is cognitive and experiential, while explicit knowledge is objective and rational (Polanyi 1958; Nonaka and Takeuchi 1995). Orr's (1990) ethnographic study of service call representatives found that, directive documentation and formally espoused tutorials and descriptions are explicit, while actual practices of organizational members are far less canonical and, therefore, tacit. Tacit knowledge is embedded in personal cognition and practices, and is, therefore, complex and difficult to transfer and share. Explicit knowledge, on the other hand, is much more formal and codifiable, and, therefore, simpler to trace, transfer, and share (Polanyi 1958). Yet, this tacit knowledge is elemental in knowledge creation. Because "an organization cannot create knowledge by itself," note Nonaka and Takeucki (1995: 85), "tacit knowledge…is the rich, untapped source of new knowledge…is the basis of organizational knowledge creation." As Polanyi (1966) remarks, "We can know more than we can tell." The knowing is tacit, the telling, explicit. It thus becomes important for organizations to offer mechanisms that can assist members to "tell" what they "know."[1]
Challenges in this phase deal with the codification of both tacit and explicit knowledge. We argue that while the creation and codification of explicit knowledge rely on the ***recognition*** of facts and patterns, the codification of tacit knowledge requires a much more careful orchestration of tacit knowledge sources to ***grasp the subtleties*** in practices, actions, and patterns, making the latter a relatively more difficult transformation.

[1] Subsumed by the tacit-explicit knowledge classification are the know-about (Nolan and Norton 1998), know-how, know-why, know-when, and know-with (Zack 1998) classifications of knowledge. Using a software innovation analogy, know-about refers to explicit or declarative knowledge such as baseline resources and scheduled timelines; know-how refers to procedural knowledge, e.g. how resources for the software innovation is allocated; know-why refers to causal knowledge, e.g., why the new software should follow a feature-driven-development (FDD) methodology or an alternative agile method. In addition, know-when refers to conditional knowledge, e.g., when milestones overrun recommended budgets; and know-with refers to relational knowledge, e.g., user-specific knowledge in a joint development. From the definitions afforded by the taxonomy, know-about and know-when knowledge classifications may be acknowledged as forms of explicit knowledge, whereas know-how, know-why, and know-with are forms of tacit knowledge.

Transforming tacit knowledge into explicit knowledge is a crucial task for organizations (Nonaka and Takeuchi 1995). In order to move tacit knowledge from the source to the seeker, firms need to interpret, articulate, and codify it into explicit knowledge. Truly, articulation of tacit individual thoughtprocesses and practices into cognizant and replicable organizational processes is immensely valuable. After all, organizations sustain themselves by trying to replicate best, albeit mutable, practices and processes rather than relying on serendipity. In this context, articulation and codification become valuable objectives in knowledge creation. The effectiveness of articulation and codification rests on knowledge agents who create an environment for shared interpretations for knowledge creation, explicating knowledge in the process.

In transforming information to knowledge, knowledge agents play the role of translators (Pawlowski and Robey 2004; Nonaka and Takeuchi 1995; Van Krogh et al. 2000). According to Pawlowski and Robey (2004), translation allows the bridging of perspectives by "reframing, explaining, and clarifying information" (pg. 659) in the context of organizational practices. Knowledge agents thus play a crucial role by communicating, translating, and interpreting perspectives within and between multiple information repositories and knowledge sources within the organization.

Knowledge agents comprise both software and human agents. While software knowledge agents deal with explicit knowledge that is objective and rational, human knowledge agents deal with tacit knowledge that is cognitive and experiential. Software knowledge agents use complex routines to create, organize, and store explicit knowledge; human knowledge agents use cognitive capabilities to manage tacit knowledge embedded in individuals and practices and convert it into explicit knowledge for use by the organization. For example, software knowledge agents can mine sales data-marts to find increasing sales in a particular location and map (translate) it to particular sales personnel. However, it requires human knowledge agents to reveal, capture, and store the tacit practices that have contributed to higher sales. At higher levels of abstraction, human agents are much more sophisticated than software agents and are thus more appropriate for interpreting and translating tacit knowledge into explicit knowledge.

The significance of software-based knowledge agents as translators results from their abilities of rule-based reasoning and combination. Software agents use rule-based reasoning (inscribed in sophisticated algorithms) to extract non-redundant information to create explicit knowledge for knowledge reuse. Rule-based reasoning in software knowledge agents incorporates a variety of business intelligence and analytic components (e.g., Bayesian networks, clustering, association rules). Using rule-based reasoning, software knowledge agents use their inscribed logic to content-analyze information and discover patterns used to create explicit knowledge. For example, software knowledge agents use sophisticated rule-based reasoning to trace decisions using forward and backward chaining, allowing them to generate knowledge maps and workflows (Ramesh and Jarke 2001). Likewise, rule-based reasoning in software knowledge agents is also used to trace potential knowledge contributors as knowledge domain experts using "who knows what" schemas (e.g. Bain & Company's "people finder") (Hansen et al. 1999).

While rule-based reasoning offers effective parsing and mapping mechanisms, combination (Nonaka 1994) allows software-based knowledge agents to aggregate explicit knowledge by categorizing, collating, and sorting explicit knowledge from different content sources (e.g., electronic forums and databases). Software-based knowledge agents combine explicit knowledge to create automatic schemas (e.g. reverse engineering) or representations (e.g., OLAP cubes) as a way to translate distributed explicit knowledge to arrive as patterns driven by analytics (e.g., association rules in recommender systems).

At variance with software knowledge agents that use rule-based reasoning and combination, human knowledge agents use their social embeddedness, instead, to take on their role as translators. Human knowledge agents reside across different organizational hierarchies and functions, from Orr's (1996) Xerox technicians to Hansen et al.'s (1999) consulting firm executives. In contrast with software knowledge agents, human knowledge agents use their abilities of socialization and externalization (Nonaka and Takeuchi's 1995) to capture tacit knowledge and convert it into explicit knowledge. Socialization is a process by which tacit knowledge is transferred from the source to the seeker by sharing practices and experiences. Human knowledge agents socialize through brainstorming and consensus building sessions

across tacit knowledge sources to extract and interpret tacit knowledge and arrive at deeper insights. Essentially, socialization allows human knowledge agents to "personalize" (Hansen et al. 1999) knowledge by transferring tacit knowledge across domains for organizational reuse. More socially networked than software-based agents, human knowledge agents use their network position to connect to multiple tacit knowledge sources to assimilate tacit knowledge through observation and dialogue. Organizational members with overly specialized domain knowledge (e.g. functional managers) often serve as tacit knowledge sources (e.g. experts). Human knowledge agents connect across these domain experts and seek out and share their tacit knowledge beyond functional and practice domains thus shifting the locus of knowledge. For example, Hansen et al (1999) describe how consultants build on their network of people to identify functional experts and get them to share knowledge by communicating back and forth about the problem they need to solve. Similarly, Nonaka and Takeuchi (1995) describe how a Matsuhita engineer, in developing an automatic breadmaking machine, apprenticed under a baker (i.e. a function expert) in order to transfer the tacit knowledge of bread making from the baker to the organization.

Once human knowledge agents seek and capture tacit knowledge from knowledge sources, the agents must externalize tacit knowledge. Externalization is a process of codifying and assimilating tacit knowledge into explicit knowledge through abstractions, metaphors, analogies, and models (Nonaka and Takeuchi 1995). Knowledge agents externalize tacit knowledge by pulling key pieces of tacit knowledge such as key points and conditional decisions and articulating them as explicit knowledge (e.g., mathematical models and notations, mental maps). Hansen et al. (1999) refer to externalization as a "people-to-documents" approach, where human knowledge agents try to interpret and codify subtleties and non-canonical practices embodied in tacit knowledge to create explicit organizational knowledge as "knowledge-sharing routines" for reference and reuse (Dyer and Singh 1998). By externalizing tacit knowledge from the experts to the organizational collective, human knowledge agents reassure the sustenance of the organization even with potential turnover of its knowledge workers.

Proposition 2a: In translating information into explicit knowledge, software knowledge agents capable of explicit knowledge discovery and combination will contribute more toward higher levels of codified explicit knowledge from information than human knowledge agents will.

Proposition 2b: In translating tacit knowledge into explicit knowledge, human knowledge agents capable of socialization and externalization will contribute more toward increased tacit knowledge sharing and tacit knowledge codification than software agents will.

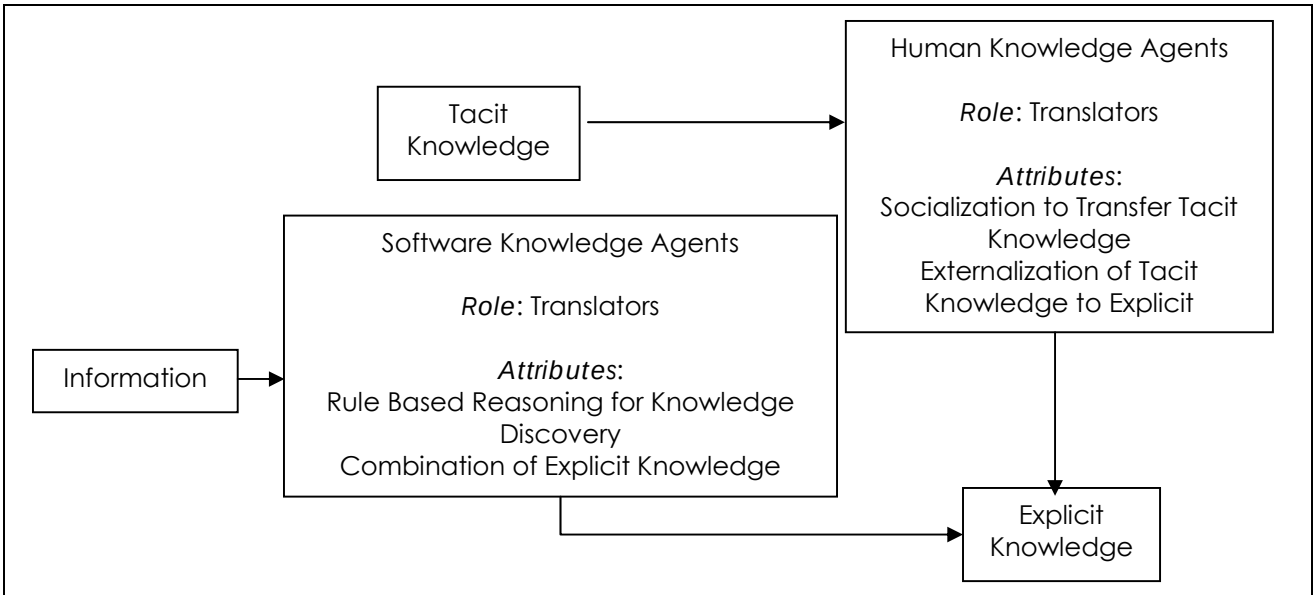

Figure 3: Knowledge Creation

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3.2. Activity B: Knowledge application

Episode 3. Transformation of Knowledge into Creativity

While there is no denying that knowledge creation is an elemental activity in knowledge management, a tradition built on knowledge creation rather than application is a costly affair leading to hoarding of, rather than the utilization of, knowledge (Van Krogh et al. 2000, Nonaka and Takeuchi 199?). It must be realized that because knowledge, per se, is a non-tradable organizational asset lacking pre-determined prices for objective valuation (Dierickx and Cool 1989), the economic value of knowledge is only ascertained by fueling creativity that leads to innovations (Nonaka and Takeuchi 1995; Decarolis and Deeds 1999). As Alavi and Tiwana (2002: 1031) note, "The ultimate objective of any organizational knowledge management initiative should be knowledge application and exploitation and not just the creation and stock piling of content." To make knowledge actionable, organizations need to foster creativity to extend their base of knowledge (Dennard 2000). "The knowledge we have is not sufficient for creating a knowledge-based business," note Von Krogh and Nonaka (2000: 21), "…the knowledge-creating company benefits from a broader mobilization of creativity and innovation." The dilemma for an organization, therefore, is to transform the stockpile of knowledge to generate ideas and innovations that can add value in the long run (Choo 1998).

Creativity is the first step toward knowledge mobilization and application. This paper defines creativity as the inception of a new idea or perspective derived from a given knowledge base. Although creativity is often a result of synthesizing existing but previously unconnected knowledge, it is a unique outcome—a knowledge artifact that extends and makes knowledge actionable and serves as a prerequisite for innovations (Von Krogh et al 2000; Sheremata, 2000).

The basis for transforming knowledge into creativity is the synthesis and cross-pollination of knowledge to create a platform for idea generation. This episode relies on the use and application of knowledge as creative concepts to promote novel ideas and perspectives pertinent to specific organizations. Accordingly, organizations must actively promote creativity for effective knowledge management. Organizations need to involve and motivate all their members to act as creative contributors, challenging them with new problems and devising incentive schemes for creative outputs and solutions.
Fostering creativity allows organizations to benefit from more than just the forwarding of knowledge. Because creative concepts are organization-specific and tacit, they offer a degree of causal ambiguity, making it extremely difficult for rivals to replicate. For example, while companies may easily reverse engineer marketed products from DuPont and 3M, they find it extremely difficult to understand how DuPont and 3M synthesize knowledge to arrive at such creative concepts. Consequently, organizations welcome the specificity inherent to creative venturing.
Promoting creativity requires the support of creativity agents. Churning creativity out of knowledge is an intermediated process where creativity agents are used to sense and respond to new business opportunities and threats (Alavi and Tiwana 2002). Creativity agents play the role of task coordinators in knowledge management. Task coordinators are brokers that can communicate laterally across the organization (Ancona and Caldwell 1992) to synthesize knowledge from different sources to stimulate and enhance creativity (Leonard and Sensiper 1998). As task coordinators, creativity agents gather a precise understanding of focal areas to determine how and where creative endeavors should be channeled, thus directing organizational members toward generating and synthesizing concepts specific to these focal areas as guided by overarching organizational strategies and objectives.

At this juncture, human creativity agents use their social connections and credence to communicate and coordinate knowledge. Moreover, because creativity is often a grassroots-level phenomenon, cross-functional managers may be well suited as creativity agents. Cross-functional managers are situated between both organizational functions and hierarchies. Owing to their situatedness in the organizational network, cross-functional managers can serve as task coordinators, effectually amplifying grassroots-level creativity and breaking down cross-functional iron curtains. For example, the assembly line worker may indeed propose a creative process redesign but will lack the voice, situatedness, or credibility of cross-functional managers to coordinate knowledge or integrate concepts across functions. This does not, by any means, suggest that all managers make good creativity agents. Only cross-functional managers who can use their situatedness (i.e. in the organizational structure and resource network) as a broker to coordinate knowledge and integrate concepts across functions can serve in the capacity of creativity

agents. Such boundary spanning behavior by key cross-functional managers as creativity agents becomes vital to idea generation and innovation (Tushman 1977). Without them, concepts generated at the grassroots level are likely to go unnoticed.

Creativity agents rely on their abilities of coordination and integration to fulfill their role as task coordinators. Creativity agents need not serve as (something missing here?) nor generally are active contributors to creativity. Rather, creativity agents actively engage in coordination and integration strategies for successful cross-pollination and synthesis of knowledge into creativity. In the context of organizational knowledge management, creativity agents coordinate creativity by aligning distributed cross-functional knowledge. For example, Ancona and Caldwell (1992) describe how team managers, as brokers, laterally melded knowledge between R&D and marketing to coordinate new product development ideas. Creativity agents coordinate the development of ideas across functions by cross-pollinating and fusing ideas and concepts using both formal and informal controls. Creativity agents can practice formal coordination through bureaucratic and behavioral control (Ouchi 1980) such as by creating and assigning cross-functional teams to generate novel ideas or solutions by building on the diversity of knowledge among team members. Creativity agents can also practice informal coordination controls based on socialization (Mintzberg 1983) such as brainstorming and brown-bag sessions across knowledge sources to arrive at and clarify new concepts.

Apart from coordinating the development and cross-pollination of ideas across functions, creativity agents also need to integrate creative ideas. Integration is a process by which creativity agents synthesize and assimilate creative silos across departments and functions. By integrating creative concepts derived from individuals and organizational collectives, creativity agents can formulate a richer set of ideas to move beyond the constraints of old knowledge. Creative ideas often exist in clusters (Rothwell 1991); only by integration can organizations synthesize disparate clusters of ideas and reduce the development of redundant creative concepts across functions. For example, Rothwell's (1991) study of innovative firms in the U.K. found that firms enhance creativity by integrating concepts across loose (decentralized) confederations. To sum up, coordination and integration allow collective reflections to be "finally crystallized into explicit concepts." In the process, creativity agents instill a culture of creativity and idea-generation and help mobilize knowledge (Nonaka and Takeuchi 1995: 86).

> *Proposition 3: As task coordinators in the transformation of knowledge to creativity, human creativity agents capable of coordinating knowledge and integrating creative ideas will generate more integrated and explicit creative concepts from the organizational knowledge base than software agents will.*

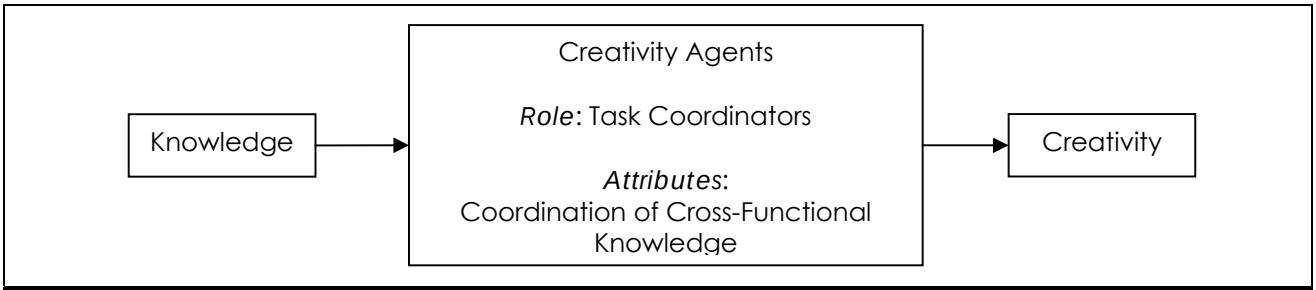

Figure 4: Transformation of Knowledge into Creativity

Episode 4. Transforming Creativity into Innovation

Creativity provides the abstraction on which an innovation is attempted; it is 'the' starting point for innovations (Rosenfeld and Servo 1990). Because of a firms' credibility as a profit maximizing entity, fostering creativity in its absolute form is not a feasible alternative; commercialization of creativity through innovation becomes an organizational imperative (Alavi & Tiwana 2002).

Innovation is defined as the successful implementation of creative ideas within an organization (Amabile 1988): It is the organization's attempt to commercialize its creativity and further push the envelope of

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knowledge application. In "The Frontiers of Management," Peter Drucker (1986) expounds: "[Creative] ideas are somewhat like babies—they are born small, immature, and shapeless. They are promise rather than fulfillment. In the innovative company executives …ask, 'What would be needed to make this embryonic, half-baked, foolish idea into something that makes sense, that is an opportunity for us?'" Kanter, et al. (1997) draw a parallel: "One of the problems in certain highly creative organizations, including many high-tech companies, is that they're very good at [creative] invention but lack the discipline needed to bring their ideas to market quickly." In short, fostering creativity is not enough; firms need to transform creative ideas into process, product, or service innovations. As the popular saying by Theodore Levitt goes, "Creativity is thinking up new things. Innovation is doing new things."

The incubation and transformation of creativity into innovations is complex. It requires concerted organizational efforts for evaluating the innovation potential of creative concepts and, upon positive evaluation, garnering resources to push the concepts toward innovations (Luecke and Katz 2003). Because creativity is a promise rather than a fulfillment, creative ideas need to be distilled in terms of their innovation potential and furthered by continuous championship as the innovation is exercised. It (what is it?) is the pragmatics of implementing ideas.

In pushing creativity toward innovation, organizations rely on innovation agents as intermediaries to play a particularly crucial role as ambassadors in transforming creativity into innovation. According to Ancona and Caldwell (1992), ambassadors are commonly experienced organizational members (e.g., senior managers) who use their position to communicate across organizational hierarchies, exerting a vital influence in molding creativity into innovations to match short- and long-term organizational goals. Innovation agents, as ambassadors, begin by evaluating and ratifying concepts for feasibility (e.g., economic, legal, political…). Innovation agents then channel ratified concepts in the form of innovation projects. As ambassadors, innovation agents also prioritize and champion innovation projects by allocating resources, thereby proactively assisting in development and implementation efforts. It is this innovation leadership that helps implement creative ideas (Nonaka and Takeuchi 1995).

In line with the aforementioned ambassadorial role, innovation agents are characterized by their abilities to assess creative concepts and to champion innovation projects (Howell and Higgins 1990). Innovation agents assess creative concepts and actively promote them as innovation projects: garnering support and access to resources as well as protecting projects from organizational interference (Howell and Higgins 1990). In an article on innovation strategizing in organizations, Adner (2006) notes how important it is for organizations to use senior managers to assess risks related to transforming ideas into innovations. According to Adner (2006), senior management assesses concepts in terms of interdependencies (e.g., cross-functional resource requirements, process and product prerequisites…) to uncover initiative (e.g., how much resource support is required) and integration challenges (e.g., whether critical resources would be cannibalized). The agent who conducts risk assessment evaluates the feasibility of embarking on an innovation project itself, the expected commercial and customer benefits from the innovation, and the relevant competition. Finally, integration risks are evaluated in terms of potential uncertainties from introducing the concept as an innovation in the value chain. A salient assessment offers a scrutiny of an organization's existing multitude of concepts in terms of their overall promise and fulfillment. For example, Ford's idea of removing dealers to sell cars online was eventually terminated by senior management because of its radical compacting of the existing value chain by displacing current dealers, thus creating channel conflict. On the other hand, Apple iPod, as a concept, was found to be more promising not only because of a promising design but also because of low initiative risks from contracting out engineering work (the iPod project team never had more than fifty employees) (Andrew and Sirkin 2007). A handful of concepts that senior management, as innovation agents, assesses and finds potential in are ratified for continued incubation and support as innovation projects (Luecke and Katz 2003).

In addition to assessing the innovative potential of competing creative concepts, innovation agents use their organizational position to champion innovation projects from a portfolio of assessed and ratified concepts. Innovation agents, as project champions, prioritize projects by creating resource buffers (Ancona and Caldwell 1992), protecting projects from undesirable interferences, and overcoming resistance (Ancona and Caldwell 1992; Luecke and Katz 2003). Innovation agents capitalize on their situatedness as senior managers in the organizational hierarchy to interconnect different organizational groups and functions to vie for organizational resources in support of their innovation projects to speed

concepts to market. For example, Motorola's satellite phone network, called the Iridium project, did not receive much needed championship to speed the concept to market. After twelve years, the concept fell prey to the more popular cellular phone networks (Adrew and Sirkin 2007). To draw a distinction, Rice et al. (2002) tell the story of how IBM's silicon-germanium chip innovation project survived because of the championing of two senior executives who not only protected the project by garnering support but also provided resources under the table to keep the project alive. It is through the championship of innovation agents that feasible concepts reach fruition as innovations. According to Schon (1963), an innovation not championed by senior management dies.

> *Proposition 4: As ambassadors in the transformation of creativity into innovation, human innovation agents capable of assessing creative concepts and championing innovation projects will contribute more toward a greater number of feasible innovation projects than software agents will.*

Figure 5: Transformation of Creativity into Innovation

Episode 5. Innovation Diffusion

Innovation diffusion is the process by which innovations are communicated over time through formal and social networks (Rogers 1965). Because innovations are archetypes that encapsulate and localize product and process knowledge involving the specific innovation (Carlile 2002), innovation diffusion offers a way by which the product and process knowledge captive to a particular innovation is disseminated as data embodied in commercial (e.g., products) and non-commercial (e.g., publications) artifacts for recreating and sustaining the knowledge management process.

Innovation diffusions are selective rather than absolute. Organizations selectively disseminate innovations in forms including commercial products (and processes), patents, publications, forums, and presentations (Nonaka and Takeuchi 1995). These are artifacts that protect intellectual property rights, provide appropriability for economic and competitive benefits, yet allow for knowledge recreation and reuse. While appropriability governs the organization's ability to capture exclusive profits from an innovation and reduce the potential for unauthorized imitation (Teece 1986; Dhanaraj and Parkhe 2006), reusability saves the organization (and, to an extent, the market) from reinventing the wheel by sharing certain aspects of an innovation as knowledge and data. By offering a crucial connection between innovation and data, innovation diffusion ascertains continuity of knowledge—completing the cycle of knowledge transformations.

Central to this knowledge transformation phase is the argument that organizations can selectively diffuse innovations for economic returns without eroding appropriability and competitive advantage. According to Baumol (2002), there are distinct market incentives from renting (commercializing) certain parts of an innovation for economic benefits while retaining the more critical parts of the innovation to inform and reengineer internal processes. The owner of the rights to an innovation can obtain the highest economic returns if an innovation is simultaneously used as an input in its own internal production process and rented for use by others. Take, for example, the way Microsoft manages its innovations. Microsoft has long focused on codifying and embedding knowledge in its software code libraries to develop software components. The component nature of software allows Microsoft to decide on which components to bundle, expose, and commercialize for profits. In parallel, it allows Microsoft to decide on which

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components to hide for internal use, protecting its core intellectual property (MacCormack and Iansiti 2002). Selective innovation diffusion not only speeds the accumulation of extrinsic (e.g., financial) and intrinsic (e.g., kudos, visibility) rewards from commercialization of products, but also benefits the firm by internalizing the more critical parts of the innovation for appropriating profits and sustaining competitive advantages.

Selective innovation diffusion benefits from combining extrinsic and intrinsic returns to maintain the continuity of knowledge. For instance, Abrahamson and Rosenkopf (1997) describe the network effects of innovation diffusion where public data from innovations are used for patent and research citations by other firms and individuals to create new knowledge. Similarly, in the open-source community, data from innovation is often disseminated for feedback (e.g., beta testing) and development. For example, Microsoft continues to derive both extrinsic and intrinsic benefits from its launching of a "shared source" initiative, where it allows an approved user base to access some parts of the "Windows Pocket PC" code (Microsoft's mobile device operating system) for feedback and modification, while masking the more critical parts of the Pocket PC source code (The Economist 2003). Other examples of innovations that have gained market share by following paths of selective diffusion have been GPS technologies and digital imaging systems (Luecke and Katz 2003). Rather than culminating knowledge application as innovations, innovation diffusion maintains the continuity of knowledge by dissipating data from existing innovations in forms of commercial products, patent, and publications- data that becomes useful to generate fresh cycles of knowledge creation and application.

Because innovation diffusion is a controlled process, diffusion agents are central to ascertaining the simultaneous appropriation from, and reuse of, innovation data and knowledge without eroding the competitive advantage of the innovating firm. Accordingly, diffusion agents take on the role of guards, controlling information flow for selective diffusion of innovations as data. According to Ancona and Caldwell (1992), guards are crucial for high-level projects (e.g. innovation projects) that have the potential of providing future competitive advantage or other important organizational benefits. Agents or brokers taking on the guard role use mechanisms to limit the diffusion of mission-critical knowledge outside the organization. Diffusion agents make sure that the innovation data made public is not sensitive enough to erode competitive advantage, thus controlling and guiding the flow of data from innovations by regulating the innovation diffusion process.

Because diffusion agents must have a thorough understanding of the competitive and strategic advantages of innovations, organizational executives are well suited to play the role of guards. Organizational executives playing the role of guards are distinguishable by their abilities to control and direct internal and external diffusion of innovation data and knowledge. Diffusion control is a process by which diffusion agents scan for environmental and market trends, delineate critical and non-critical parts of an innovation, and regulate the dissemination of innovations in accordance with organizational objectives. Diffusion agents closely track market trends to ascertain opportunities for disseminating innovation data for profitability and exposure, yet control essential elements for reuse within the organization—thus localizing knowledge from innovations. For example, ***embedded*** Linux, a commercial open-source software (OSS), uses a control technique called ***selective revealing*** to disseminate only parts of the source code and protect critical parts of the code for strategic and economic advantages (Henkel 2006).

In addition to controlling diffusion, diffusion agents also direct the diffusion process by mapping paths and resources required for extra-organizational and intra-organizational diffusion of innovation knowledge and data. Diffusion agents direct the diffusion of non-mission critical data from innovations in two ways. First, they direct the dissemination of basic innovation data embedded in commercial products and services in the form of ingredient lists and features, thus generating a steady state of Schumpeterian rents and competitive first-mover advantages (Nerkar and Shane 2003). Second, they direct patent and publication strategies to ascertain strategic returns from the open (public) availability of pre-selected parts of the innovation data. Innovation agents often direct the choice of publication outlets and devise patent formulations so that data from innovation is publicly shared and widely cited for reuse without sacrificing intellectual property privileges required for a sustained appropriation of benefits.

Intra-organizational innovation diffusion, however, requires a different form of direction by diffusion agents. Since innovation activities "generate a wealth of knowledge that's a result of struggles" (p. 224, Hargadon 1998), it is the responsibility of diffusion agents to recirculate this knowledge internally as a template for future innovations. In practicing intra-organizational diffusion of innovations, diffusion agents direct the transfer of mission-critical innovation data (e.g., test data, machine and labor setups, undisclosed operational techniques) back to internal databases for transformation into information. They do this by invoking and relying on software and human knowledge agents. Diffusion agents direct software knowledge agents to combine explicit knowledge from innovations (e.g., prototype iterations and features) and add them to the organizational knowledge base, or they can direct human knowledge agents to map and codify the innovation process, therefore capturing tacit mission-critical innovation knowledge. Tacit mission-critical knowledge includes understanding issues surrounding project failures, pitfalls (e.g., resistance), resource linkages, and employee scheduling and interactions in the context of the innovation.

The ability to control and direct innovation diffusion allows diffusion agents to routinize innovations by making innovations a part of ongoing organizational activities. Moreover, by directing intra-organizational diffusion of innovations, diffusion agents create internal knowledge markets by demanding and employing other agents and resources (Hansen and Haas 2001).

By controlling and directing the selective diffusion of innovation, diffusion agents simultaneously encourage the continuity and reuse of data and knowledge while maintaining causal ambiguity surrounding the underlying mechanisms based on which the innovation was attempted (Dierickx & Cool 1989). In short, diffusion agents systematize and routinize innovation diffusion to maintain the cycle of knowledge creation, application, and most of all, knowledge reuse.

> *Proposition 5: As guards in the transformation of innovations to data and knowledge, human diffusion agents capable of selectively controlling and directing innovation diffusion will contribute more to higher levels of intellectual property assurance and increased data and knowledge reuse than software agents will.*

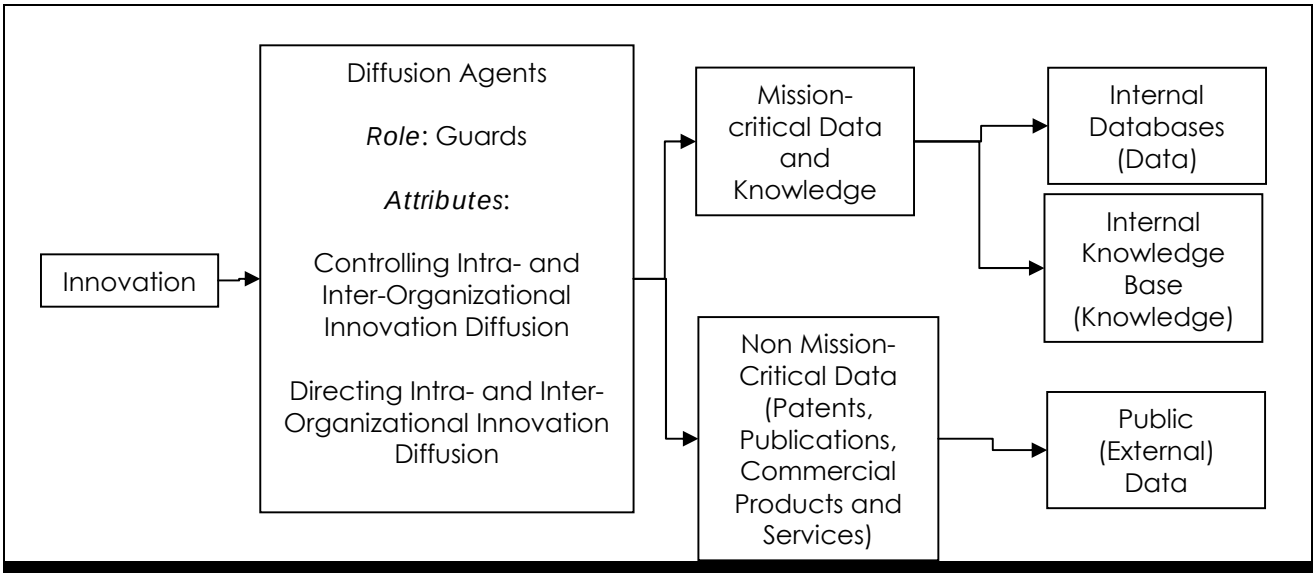

Figure 6: Innovation Dissemination

4. Discussion

When organizations embark on KM initiatives, a common concern they face is a lack of understanding how to structure and organize their KM process to garner economic benefits from the creation and

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application of knowledge. Addressing this concern, this paper synthesizes work from separate fields of inquiry to interpose an agent-mediated perspective on conventional KM paradigms. The agent-mediated KiM model offers a relative degree of hypothetical novelty as a departure from conventional discourses on knowledge management by rethinking KM as a series of dynamic agent-mediated transitional episodes linking knowledge creation and knowledge application. Because this research offers a KM process metamodel, the proposed agent-mediated KiM model introduced in this paper can be extrapolated to most organizations involved in trying to manage and secure returns from knowledge. Altogether, the agent-mediated knowledge-in-motion model suggests the following conclusions:

First, knowledge management is an essentially agent-driven phenomenon. The use of different agents in the creation, synthesis, and application of knowledge is a function of their roles and attributes. Agents in knowledge management bridge knowledge transitions leveraging on their situatedness within the KM process. Consequently, particular types of agents (phase-specific software, human, or a combination of software and human agents) correspond with specific knowledge management phases. Agents in KM play a multitude of roles. During knowledge creation, agents scout data for information and translate information into knowledge. During knowledge application, agents coordinate knowledge into creativity, serve as ambassadors to champion innovation projects from a refined set of creative ideas, and act as guards for selective innovation diffusion. Every role requires an attribute set that allows agents the capacity to serve in that particular role. The agent typology, along with corresponding roles and attributes of agents, is tabulated in Table 1.

Table 1: Agent Typology, Roles, and Attributes in Knowledge Management

Agent Typology	KM Phase	Agent Role	Software Agent Attributes	Human Agent Attributes
Information Agents	Data to Information	Scout	Modularity and Standardization	-
Knowledge Agents	Information to Knowledge	Translator and Interpreter	Rule-Based Reasoning and Combination	Socialization and Externalization
Creativity Agents	Knowledge to Creativity	Task Coordinator	-	Coordination and Integration
Innovation Agents	Creativity to Innovation	Ambassador	-	Assessment and Championing
Diffusion Agents	Innovation Diffusion	Guard	-	Control and Direction

Second, knowledge management relies on the complementing and combined effects of software and human agents. Software agents are excellent at objective parsing using standardized logic. Software agents can easily be inscribed with complex routines and are particularly effective when assigned structure and parameters (e.g. decision rules). As long as declarative criteria and conditions are met, software agents surpass human agents in handling the complexities of objective data and information. Human agents, on the other hand, surpass software agents in handling subjective complexities of reinterpretation and recontextualization requirements (Kogut and Zander 1992). While software agents embody a more consistent and standardized logic for routine iterations, is the relative lack of embodied standards and routine processing that makes human agents more suited to less-standardized activities that require ad-hoc communication and negotiations (D'Addrerio 2003). Correspondingly, software agents are appropriate for phases that require transformations based on objective criteria (e.g., modularity, combination), whereas human agents are suited for phases that require transformations based on subjective and social criteria (e.g. socialization, coordination, championship, and direction).

Third, knowledge application should complement knowledge creation to maintain continuity of knowledge. The management of knowledge must encompass the acquisition, interpretation, storage (codification) and distribution of knowledge (Huber 1991). Knowledge acquisition requires restructuring of data and the reinterpretation of information to assign shared meaning. Shared interpretations require transferring knowledge from the individual to the organizational collective for storage and further transformation into concepts to be implemented as innovations. Finally, to ascertain reuse, knowledge

and data from innovations need to be selectively diffused within and beyond the organization for profit, exposure, and recreation. Creating knowledge without applying knowledge leads to the stockpiling of content that is absent of economic or strategic value. Application of knowledge comes from using existing knowledge to develop concepts, transforming concepts into innovations, and the subsequent diffusion of innovations for the appropriation and recreation of information and knowledge. Application of knowledge can ascertain economic returns and maintain knowledge as a source of competitive advantage while furthering knowledge reuse. Without proactive efforts toward knowledge application, knowledge merely incurs costs of acquisition and storage yet fails to deliver instrumental benefits from its presence.

Contributions

The paper contributes to our understanding of knowledge management research and practice in several ways. First, the paper adds to existing research on knowledge management by combining knowledge hierarchies and process transitions to create a cycle of knowledge creation, application, dissemination, and reuse. By assimilating hitherto fragmented views of knowledge, the agent-mediated KiM model highlights the transitional nature of knowledge without succumbing to any specific perspective (e.g. knowledge as an object, a hierarchy, a capability). The research also moves beyond assigning importance to specific types of knowledge (e.g. tacit versus explicit, know-how versus know-when) or specific phases of knowledge transformation. In doing so, the paper underscores and synthesizes various lines of arguments to provide a holistic view linking knowledge creation to knowledge application. Building on the contention that "knowledge management is not a monolithic but a dynamic and continuous organizational phenomenon" (Alavi and Leidner 2001: 131), the paper focuses on unraveling how organizations can use human and technology resources as agents to encourage the creation, application, and dissemination of knowledge without capitulating to a single activity.

Second, the paper forwards an agent typology to offer insights on KM intermediaries who play a key role in creating, transforming, applying, and diffusing knowledge. Investigating KM as an agent-mediated process surfaces the underlying granularity of the process, adding a richer texture. Prior work on KM mainly emphasized the antecedents and outcomes of knowledge with little reference to key intermediaries in KM. Yet, agents are core to every transformation episode. Agents perform brokerage functions ranging from querying to linking and translating knowledge in its many states and forms. As facilitators in KM, agents establish an organizational ***ba*** (a shared domain or place for the exchange of knowledge) (Nonaka and Takeuchi 1995). At every episode of KM, the agents use the ***ba*** to extract, translate, transform, and pollinate various knowledge transitions for active and continuous learning. Every transformation episode requires different types of agents with distinct repertoires. Regardless of whether agents are software or human, agents in knowledge management perform essential brokerage functions to smooth the transition and cycle of knowledge creation and application. Furthermore, the agent perspective shifts focus to action and process instead of position and structure, thus restating Burt's (1992) notion that it is not only the position but also the attributes of the agent that actually turn a structural position into a key resource (Dhanaraj and Parkhe 2006).

Third, the paper offers cues regarding the employing of software and human agents for knowledge management. In the activity of brokering, KM agents, software or human, must manifest both distance and legitimacy in KM transitions. KM agents need to be cautiously introduced, developed, and maintained as bridges for specific knowledge transformations, so as to ascertain that the agents can positively influence KM transitions without being pulled in as a full member or being rejected as an outsider. For software agents, it requires that developers do not construct a biased application logic inclined toward maintaining a particular state (e.g., a goal-seek logic biased toward maintaining or reaching particular values for fulfilling organizational expectations). Often, incentives based on KM metrics add to such biases. For example, in recruitment KM systems, developers can manipulate functions to reduce or add "action words" to fulfill application quotas suggested by organizations. In the case of human agents, care has to be taken in making sure that the human agents are not biased with individual agendas that can unfairly influence the process. For example, a senior manager, as an innovation agent, may be guided by bias rather than feasibility assessments in choosing one idea over the other.

Fourth, the paper clarifies the need for ***knowledge application in addition to knowledge creation***. In literature on knowledge management, knowledge application remains understudied. Often fueled by the

concept that increased knowledge accumulation automatically leads to knowledge application, firms assume that knowledge creation is a final outcome of KM. Under this assumption, knowledge creation is treated synonymously with knowledge application, without much effort expended toward accomplishing the latter. While knowledge creation may be a necessary condition for achieving competitive advantage, it is not a sufficient one (Alavi and Leidner 2001). Therefore, for firms to create and sustain competitive advantage, knowledge not only needs to be created but also effectively assimilated, applied, and disseminated in everyday practice.

Finally, the paper highlights the process by which ***knowledge can be used and reused*** without compromising its integrity and context. The KiM model offers a holistic view of KM as a dynamically transitional process that asserts the continuity of knowledge by its use and reuse. For managers, the framework prescribes a unified view of the KM as a reference template for organizations to assess their own KM effectiveness and outcomes. The KiM model traces KM as a multi-episode cycle of simultaneous knowledge creation and application. The model further reveals the mutability of knowledge as it is contextualized for organizational use and then re-contextualized during dissemination for reuse. To sum up, by moving away from a hierarchical to a transitional agent-mediated view of KM, the KiM model offers a systematic KM routine based on distinctive ways companies can exploit knowledge without sacrificing the free-flowing nativity of knowledge. Understanding that "without a systematic routine…, a firm might not benefit from its best knowledge being captured" (Alavi and Leidner 2001: 121), the agent-mediated KiM model allows us to derive a systematic perspective of how knowledge can be explored and exploited to generate economic returns.

Implications for Future Research

Like all other studies, this study is limited in its scope, and some caveats are in order. However, these limitations of scope serve as stepping stones to guide future research. First, the level of abstraction used in this paper may be an oversimplification of the organization and management of knowledge. A key opportunity for future research is to tease out a richer and more intensive investigation of the ***effectiveness of intermediaries*** as transformation agents. As catalysts, transformation agents perform brokerage functions in a collaborative knowledge environment. Knowledge transformations within the KiM model are induced by the effectiveness of these agents. For the sake of simplicity, this paper assumed homogenous agent effectiveness across all episodes of transformation, focusing more on the process of transformation rather than on its effectiveness. However, agent effectiveness is seldom homogeneous. Rather, effectiveness is a function of multiple factors. For example, how would agent effectiveness vary if the content or sources of input change? If the input content is more complex, diverse, and distributed, would it reduce agent effectiveness? How effective would agents be if input sources were resistant to share data, information, knowledge, or ideas? Does agent effectiveness vary across transformation episodes or by industry, or both? Such research questions seek to probe underlying tensions surrounding the use and outcomes of agent mediation in knowledge management.

The second research direction shadows the first and concerns the need to elaborate on the ***contingencies that shape agent-mediated knowledge brokering*** efforts. Among them, "research that focuses on social, cultural, and technical attributes of organizational settings that encourage and facilitate knowledge flows…is important" (Alavi and Leidner 2001: 121). We believe that these attributes, individually and collectively, can significantly influence KM brokerage activities by manipulating the congeniality, sharing, and supporting of KM activities. First, social settings can offer interesting cues about how organizations structure themselves to promote associations, interactions, and linkages, subsequently creating opportunities for different types and forms of brokerage (i.e., Do particular social structures promote KM brokerage more than others? If so, what particular social attributes surface to differentiate such brokerage opportunities?). This issue also touches upon the strength of ties in KM brokerage, allowing us to question whether particular social structures build on weak or strong ties. Second, cultural settings can offer insights about the shared rules that govern a spectrum of organizational behaviors (e.g., co-opetition versus competition among organizational members), factors crucial to KM and related brokerage opportunities (e.g., How does and what aspects of organizational culture affect KM? Are there certain cultural templates that accommodate KM brokerage more than others?). Third, technical settings can allow for a better understanding of whether and how available technologies can enable KM efforts, including brokerage opportunities (e.g., What are the technical prerequisites to effective brokerage

function across different phases of knowledge transformation? Can KM systems provide the essential infrastructure to streamline continuous knowledge creation and application?)

Third,(It is confusing to have an embedded numbering system) this paper does not offer concrete advice on the metrics needed to gauge the effectiveness of every phase of KM transformation. Further ***delineation of metrics*** is paramount to assess agent-mediated KM transformations. At every phase of the KiM model, knowledge states undergo transformation and refinement, leading to distinct process outcomes. However, what are the metrics that define such agent-mediated transformations? Are these metrics based on the quality or the quantity of the outcome? Is there a difference between the quality of knowledge outcomes (innovation diffusion, information, knowledge, creativity, innovations) and the quantity (e.g., number of creative ideas or the terabytes of information)? Do specific KM transitions require a particular choice of metrics? Do these metrics differ across organization and industry?

Further, it is important to clarify that the proposed activities and episodes in the agent-mediated KiM model are distinguished as discrete mainly for theoretical and analytical distinction, typical of "the ideal type" construction in Weberian theory. However, it must be understood that the discrete phases and episodes used to depict our agent-mediated KiM model are, in reality, seldom discrete. Instead, reality is often suggestive of degrees of overlap between KM phases and episodes. Moreover, in the scope of our discussion, it is assumed that knowledge transitions are deterministic, i.e., an unbroken chain of prior transformations causally determines every future knowledge transition. While this view may have analytical merit, a more granular investigation of specific knowledge state transitions could offer potential benefits for research and practice. For example, are trasitional states fuzzy? Where does knowledge creation end and application begin? Are there discrete markers? Perhaps further investigation of each transition state could better surface the underlying preconditions in this KM research.

Fourth, in the scope of our discussion, agents, as catalysts, positively influence knowledge transitions. Given the positive influence, one could presume that the more agents an organization employs, the more streamlined its knowledge transitions. However, one could equally contend that a proliferation of agents (software or human) could likely lead to a ***tragedy of the commons***, leading to diminishing returns as too many agents try to vie for limited knowledge resources. In any phase of knowledge transition, the presence and availability of agents positively contributes toward knowledge transformation. However, as more agents are introduced, managing the agents is likely to increase in difficulty, contributing to a decrease in the effectiveness of agent-mediatied knowledge transitions. Several questions arise: Will more agents always lead to higher levels of transformation? Are their effects on KM transformations linear or non-linear? Is there a threshold (i.e., optimality) for the number of agents a particular phase can support? How different are the thresholds? Further investigation of agent effectiveness in the light of diminishing returns to scale could possibly lend interesting insights on the issue.

The final issue concerns our choice of methodology. The agent-mediated KiM model is a rational deduction, grounded only by theoretical underpinnings, aimed at suggesting a KM process roadmap for researchers and practitioners to follow. As an obvious extension, an ***empirical validation*** of the model would be helpful. Empirical evidence may offer insights into best practices as well as impediments to successful KM transformation. Such an exercise would complement the KiM model by bridging theory with organizational reality. KM, as an organizational reality, is equally marked by impediments. While this research aimed at eliciting successful KM transformations, without reflecting on the impediments, the KM process remains partially understood. An investigation of KM efforts highlighting both problems and prospects related to agent-mediated KM would immensely benefit our existing body of knowledge.

While more theoretical and empirical work can elaborate and verify the KiM model, I believe that a useful starting point has been made. This paper presents a systematic approach to agent-mediated knowledge creation, application, and reuse. This paper also distinguishes the choice of human and software agents in KM phases, therefore creating an agent typology to inform research and practice on the roles, attributes, and accomplishments of key intermediaries in the KM process. This agent-mediated KiM framework unites knowledge creation and application as a perpetual cycle of knowledge transitions. Overall, the proposed agent-mediated KiM model lets us examine the complexities of resource transformations, agent-mediation, and event transitions as organizations seek economic and strategic sustenance from their KM activities. As creators, users, and disseminators of knowledge, researchers and practitioners should find the

proposed agent-mediated KiM model useful in their future quests to further explore and exploit knowledge.

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About the Authors

Pratim Datta completed his Ph.D. and M.S. in Information Systems and Decision Sciences from Louisiana State University. Having served as a faculty at Washington State University, Pratim plans to join Kent State University in the Fall of 2007 as an Assistant Professor of Management and Information Systems. Pratim's research interests include Information Systems Design, Reengineering, and Assurance, Technology Commitment, and Consumer Behavior in Electronic Markets. His research has appeared in journals including the *Journal of the Association of Information Systems*, *IEEE Transactions*, *Information Systems Frontiers, The Information Society,* and *The Journal of The American Society of Information Systems and Technologies* and in proceedings of major information systems conferences including *International Conference on Information Systems (ICIS*) and *European Conference on Information Systems (ECIS)*. Pratim has over six years of industry and consulting experience in information systems design and deployment

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