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Dynamics of Knowledge Integration in a Project Network

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Abstract

Recently, there has been a tendency in many industries to form collaborative projects with the objective of creating value for customers. Flow of resources, especially knowledge, is quite common among actors of a project network. However, disparate knowledge has to be integrated in the network in order to accomplish project objectives. Due to the paucity of literature on how the actors of a project network integrate their specialized knowledge; this study undertakes the task of examining the process of knowledge integration in a large project network. Based on the existing literature, a conceptual framework for knowledge integration was developed and, subsequently, a longitudinal study of a large network was designed to observe the phenomenon. The study revealed interesting insights into the dynamics of knowledge integration by suggesting that knowledge identification is an important subprocess and how it influences the later subprocesses of knowledge integration.

Key words: knowledge; integration; projects; network

JEL classification: M10

1. Introduction

Developing economies (e.g., India, China, Brazil) all over the world are implementing large infrastructural projects with the objective of promoting overall growth to the economy and enhancing competitiveness. More often than not, government is an important stakeholder in such projects, as they not only have to ensure all round economic development but also because infrastructure development is still under the purview of governments. The projects range from developing roads, railways, airports, and shipyards to improving communication by building telecommunication networks. In order to accomplish these projects, which usually require integration of diverse knowledge and capabilities, they are designed as multiparty and multi-activity projects; a typical example of which is a construction project.

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The main reasons for devising project networks is the customers demand for customized products, competitive prices, and prompt delivery (Sandhu and Helo, 2006, p. 600). As a consequence, firms have to use their specialized resources employed in a network or collaboration to access different intangible resources. Knowledge, one of the important resources, has assumed the role of a strategic resource not only for the companies operating autonomously (Cricelli and Grimaldi, 2010, p. 348) but also for the companies joining in networks or inter-organizational collaboration with customers, competitors, suppliers, sub-contractors, and partners (Ritter and Gemünden, 2003, p. 692). Such co-creation of value can easily overcome the lack of competencies and resource scarcity while dealing with the complexity of designing and implementing large infrastructural projects. However, the practice is not devoid of challenges that arise due to multiple knowledge bases of the respective partners and the temporary nature of alliances that are formed to deliver new outputs together (Dietrich et al., 2010, p. 60). The challenge is not only to identify the relevant partners but also to manage expectations of each partner during the process.

Even though there are many separate studies on project networks and knowledge integration, there are very few which have looked at them together and still fewer which have examined the process of knowledge integration in a project network. Thus, a key aim of this article is to explore the process of knowledge integration in a project network environment and provide relevant answers to pertinent questions.

In the next section of this article, we discuss relevant concepts from existing literature, e.g., knowledge integration and project networks. We discuss the various steps in the process of knowledge integration in a project network and its outcomes. This section also identifies research gaps. The next section formulates the research questions and the research method adopted for the study. Following this, we discuss the context of a project network in which the study has been carried out. Finally we end with an in-depth analysis and discussion. We also suggest a normative model of knowledge integration in a project network context, indicate the limitations of this study, and suggest directions for future work.

2. Literature Review

Businesses have started to adopt a project network approach to managing large scale activities like construction of power plants, aerospace facilities, military installations, telecommunications, and other types of infrastructure. But due to the complexity related to technical and economic issues involved and the large amounts of resources required, clients prefer to buy whole projects from sellers (contractors), who offer project planning, implementing, and management. For the sellers, such a deal is profitable and provides a strategic form of differentiation and expansion (Sandhu and Helo, 2006, p. 601; Gunter and Bonaccorsi, 1996, p. 533). Many projects involve large-scale provisioning of an integrated package of resources to provide technical and economic solutions. This requires an array of resources, capabilities, and activities and thus involves cooperation with other firms (actors) apart from immediate clients, including consultants, sub-contractors, financial institutions, government ministries, regulatory organizations, and quasi-government organizations. This cooperation of clients and actors in marketing, planning, and implementation of the project forms a project network. The project purchaser and project seller are the main actors in the network, but other important actors include consultants, major sub-contractors, and political and regulatory authorities. The formation of a network is an inevitable corollary of project business (Dubois and Gadde, 2002, p. 554). Recently, the number of studies on project networks addressing relationships between firms has increased considerably (e.g., for inter-firm projects, see Soderland, 2004). Artto and Wikström (2005, p. 344) define a project network as a "business of several firms: project network is the part of businesses that relate directly or indirectly to projects, with a purpose to achieve objectives of a firm or of several firms."

Project networks are a preferred mode of delivering results because of the characteristics of large scale or hi-tech projects. Such projects are usually unique, complex, and discontinuous. Uniqueness results from the fact that every project differs in size, type, customers, suppliers, construction, price, and so on. It is complex in terms of the technical, financial, political, and social factors involved. Finally, it is discontinuous in terms of a high degree of discontinuity in economic relations between suppliers and customers. Thus, Hellgren and Strernberg (1995, p. 379) define a project network as a set of relations where no single actor may act as a legitimate authority for the network as a whole.

Project networks are temporary networks consisting of several organizations or actors (Dubois and Gadde, 2002, p. 554). The network aspect emphasizes that no actor alone has a total control over the network (Powell, 1990, p. 298). The temporary nature of project networks means that they exist in the specific form only during the time line of a single project. Project networks can be seen as instruments of achieving specific, pre-defined targets. At a glance, it may appear that these mutual pre-defined targets act as a temporary underlying force of gluing the project network actors together (Hellgren and Stjernberg, 1995, p. 380). Nevertheless, the individual actors involved in the temporary project networks might have other rationales and motivations for their participation than only fulfilling the specific short-term project tasks. The temporary project network is also impacted by long-term business interests and objectives of the actors as organizations involved in one project often also participate in the next (Eccles, 1981, p. 336). Therefore, for an actor the participation in the short-term project network can also be a means to reshape the position in the underlying permanent project business network (Hellgren and Strenjberg, 1995, p. 380). In addition, the roles of the actors might be changing from one project to another, making a partner in one project a competitor in the next (Artto et al., 2008, p. 345).

Another aspect governing the formation of project networks is that they are loosely coupled apart from being decentralized (Orton and Weick, 1990, p. 205). This also applies to the knowledge dimension. Relevant pieces of knowledge are distributed (Tsoukas, 1996, p. 13) into multiple local settings and also reside in individual members. The work undertaken in the project network is temporary in nature in the sense that it has a starting and completion date. Thus it is a temporary and dynamic arrangement with greater emphasis on goals, which are to be met within money and time constraints (Koskinen, 2010, p. 263). In other words, project networks experience immense dependence on this scattered knowledge. Hence integrating knowledge in a project network is a critical element to the performance of this productive system (Corvello and Migliarese, 2007, p. 10).

Knowledge integration (KI) refers to the ability of the project network to turn knowledge into action. Given the issues related to transferability and appropriability of knowledge (Grant, 1996, p. 112), it is usually difficult to integrate knowledge. Authors therefore suggest that organizations develop capabilities in order to integrate specialist knowledge from different competence areas. Gold et al. (2001, p. 187–195) identify IT, organization structure, and culture as infrastructural capabilities required to achieve KI. However, governed by the logic of efficiency, organizations having specialist knowledge tend to form project networks, allowing faster integration of that knowledge. The flexible organization structure of a project network encourages knowledge flow and collaboration across boundaries within the network (Leonard-Burton, 1995, p. 39). The project network competitiveness depends on the diversity and strategic value of specialized knowledge and its ability to integrate this in an effective manner. KI thus can be seen as "an ongoing collective process of constructing, articulating, and redefining shared beliefs through the social interaction of organizational members" (Huang, 2000, p. 170) and helps high performing project network teams to achieve and manage complex tasks and activities. However, Huang et al. (2001, p. 165) argue that current conceptualization of how knowledge is integrated within the context of project networks remains limited. It is therefore important to explore the dynamics of KI within and beyond the boundaries of high-performing project networks, generate new ideas, and understand the strategic and complex change initiatives (Dietrich et al., 2010, p. 124).

Kraaijenbrink et al. (2007, p. 1215–1233) also summarize this concern, "Scholars regard KI as a black box or elaborate on explanatory models of successful KI" (e.g., DeBoer et al., 1999; Hamel, 1991; Hansen, 2002; Lane and Lubatkin, 1998; Monery et al., 1996; Szulanski, 1996; Zander and Kogut, 1995). As such they provide an understanding of outcome of KI but less so of the process.

The importance of KI in a network has been aptly summarized by Moller and Svahn (2006) that "the division of labor allows network members to specialize in the value-creation activity supported by their own distinctive competence, thus leading to increased efficiency." Specialization, while allowing firms to economize, increases their interdependency. Today, most firms cannot pursue major innovations or systemic product offerings alone because of the dispersion of knowledge and technological resources. Firms try to overcome this by seeking knowledge transfer and joint creation of new knowledge through vertical and horizontal networking. In this respect, a firm's capability of influencing and leveraging various networks can have a significant impact on its market and financial performance (Moller and Svahn, 2006, p. 897).

The primary aim of this article is therefore to study the process of KI in the project network.

3. Process of Knowledge Integration

Actors in the project network seek specialized and complementary knowledge from other actors in order to meet the objective of the network. This search for knowledge suggests that network actors must engage in the process of identifying relevant knowledge partners. Only the identified knowledge can be acquired and utilized to accomplish the network goals. Thus, in case of project networks, knowledge identification becomes the first step of KI process (Kraaijenbrink et al., 2007). The authors further observe that, in a growing literature on knowledge management, several studies have focused on knowledge utilization and partially on knowledge acquisition, but not on knowledge identification. Knowledge identification should precede knowledge acquisition since only identified knowledge can be acquired (Kraaijenbrink et al., 2007, p. 1217).

3.1 Knowledge Identification

The literature on information seeking and environmental scanning suggests that the knowledge identification stage could be in a continuous interplay between knowledge seeker and source, eventually leading to a compromised knowledge need "between source and seeker." Daft and Weick (1984, p. 287–291) and Choo (2001, p. 57) identify the level of intrusiveness of the seeker as a distinguishing aspect of information seeking behavior. When the levels of intrusiveness of both source and seeker are seen as dichotomies, four identification subprocesses can be distinguished. The first subprocess—high intrusive seeker, low intrusive source—is intentional search. Aguilar (1967, p. 74) refers to this as respectively formal or informal search. In this mode, the seeker actively seeks knowledge outside the company, for example, on the internet, trade fairs, or in personal network. The second subprocess (low-high) is unsolicited presentation of knowledge by the source. An example is the dissemination of information on new technologies by a source to potential partners. The third subprocess (low-low) is accidental discovery and occurs, for example, when the seeker browses the internet without having a particular need for information. This subprocess is similar to what Aguilar called undirected and conditioned viewing. The fourth theoretically possible subprocess (high-high) is believed to be not relevant, because it is dependent on who is most intrusive, it will be similar to intentional search or unasked presentation from the perspective of the seeker. For example, when the seeker is most intrusive (i.e., she finds the source), it is expected that she will not be able to correctly establish whether the source has been intrusive or not.

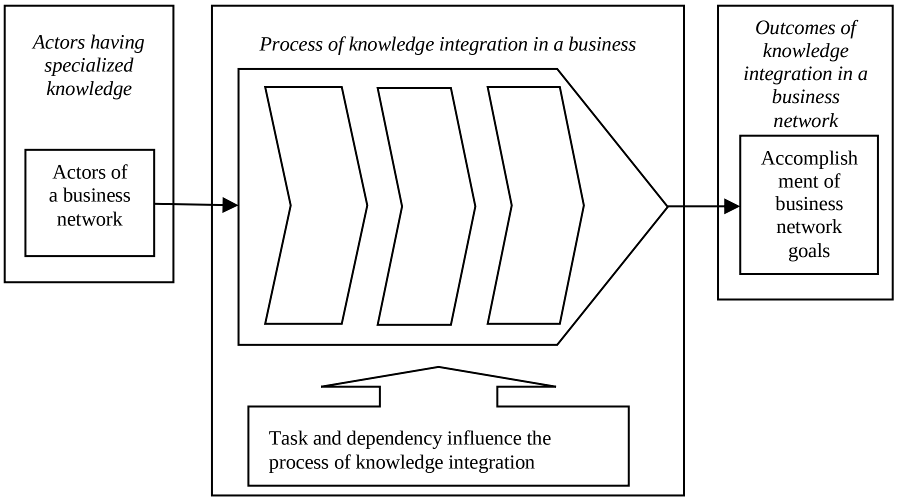
3.2 Knowledge Acquisition

In the knowledge acquisition stage, knowledge has to be transferred from a source to an organization. This transfer can take several forms, ranging from a document transfer (for explicit knowledge, cf. Nonaka, 1994, p. 17–34) to interactive cooperation (for tacit knowledge). Kraaijenbrink et al. (2007, p. 1218) base a more fine-grained distinction of acquisition subprocesses on several possible carriers of knowledge. First, knowledge that is codifiable can be represented in written form and transferred in documents or files. Second, physical objects can be transferred from the source to the recipient. An example in new product development is reverse engineering a competitor's product (Becker and Zirpoli, 2003, p. 1037). Third, the people that carry knowledge can be transferred by hiring or employing them. This is common practice in Japanese companies (Dyer and Noboeka, 2000, p. 720). Fourth, people can also transfer their knowledge without necessarily being employed, for example in the form of courses. Fifth, when knowledge is embedded in work processes, transfer of knowledge is possible by cooperation between the source and the recipient, for example by cooperative development. Finally, when knowledge is embedded in the source organization's structure or culture, it can be acquired by outsourcing a problem to the source and staying in contact.

3.3 Knowledge Utilization

The knowledge utilization stage consists of actions in which knowledge is obtained, i.e., made accessible, applied, and integrated in the organization. Each of these three subprocesses can take place as a one-time-only static process or as an ongoing dynamic process, which suggests six subprocesses within this stage. Providing access on a one-time-only basis is done by storing knowledge somewhere in the organization, e.g., in archives or individual people. The corresponding dynamic subprocess is that of diffusion. Using the image of a jigsaw puzzle, Galunic and Rodan (1998, p. 1195) distinguish two forms of diffusion: distribution and dispersion. A picture on a jigsaw puzzle is distributed when each person receives a photocopy of the picture. The same image would only be dispersed when each of the pieces is given to a different person. One-time application of knowledge is the process of putting the obtained knowledge to use in the situation it was needed for. Ongoing application can be referred to as knowledge reuse or exploitation (March, 1991, p. 73). The integration of knowledge on a one-time-only basis is what Grant (1996, p. 114) has called direction: codifying tacit knowledge into explicit rules and instructions so that it can be communicated at low cost throughout the organization. Grant calls a second form of integration routinization. An organizational routine is "[a set of activities] routinized to the extent that choice has been simplified by the development of a fixed response to defined stimuli." Figure 1 shows the conceptual model of KI in a business network based on a literature survey.

Figure 1. Conceptual Model of Knowledge Integration in a Business Network



4. Research Design

The research question indicates a qualitative approach because (a) the study is exploratory in nature; (b) the goal is to understand a phenomenon in the context of project networks, which requires understanding the unit of analysis in its natural setting and the meaning that people attach to their everyday business experience (Poggenpoel et al., 2001, p. 412); and (c) one has to abstract ideas and concepts from raw data (Crowley et al., 2002, p. 42) and understand the reality as perceived by the participants (Cresswell, 2003, p. 55). The strength of a qualitative method lies in its inductive nature, its focus on specific situations or people, and its emphasis on words rather than numbers (Maxwell, 1996). Data have to be collected through multiple means to provide a deeper and more comprehensive understanding of the phenomenon. Qualitative research is considered to be useful in all such situations (Yin, 2003, p. 35).

The study was conducted using guidelines laid down by Yin (1994, p. 52) and Eisenhardt (1989, p. 543), which ensure that the rigor for a positivist case study is duly maintained. Cepada and Martin (2005, p. 343) also stress that a positivist case study can offer valuable and valid insights from qualitative data, provided it has been designed to satisfy the criteria laid down by this particular stance, as suggested by Benbasat et al. (1987, p. 374), which meant obtaining first-hand knowledge of subjects.

A single case study with embedded design was adopted for this study. Data were gathered using observations, interviews, and other documents.

As the study is aimed at providing an insight or refinement of theory, it is instrumental in nature (Stake, 1996, p. 249). Being an instrumental case study, opportunity to learn, typicality, and accessibility were used as the criteria for selecting the case.

The project network in this study (TAXNET) comprises 9 actors. Given the burden of collecting data from 9 organizations in multiple forms, the study is an in-depth case of a single project network. The formal access for this study was granted in September 2008 and the task for data collection began in October 2008. Data collection finally ended in March 2010. This time frame allowed us to gather data from multiple sources and at multiple levels. We were also able to revise the conceptual understanding on the basis of new empirical insights.

The main source of data was 25 in-depth theme-based interviews, which were conducted in two phases during the period 2008–2009. In the first phase, 5 theme interviews were conducted focusing on the details of the project, the relationship with other actors, the activities performed by co-actors, types of knowledge required to perform those activities, challenges faced by each actor during the course of project implementation, and the major decisions taken by the players. The first phase of interviews was mainly conducted for the level of project managers and other senior level executives. The second phase consisted of 20 interviews which were conducted for participants for all levels, managers to field engineers. These interviews averaged 80 (range 50–120) minutes and were conducted for all participants from all the organizations involved in the TAXNET project.

We adopted the purposive sampling procedure with snow ball sampling to select the participants. Respondents were chosen because they provided best access to information. The idea was to gather different perspectives on the phenomenon, as the interviewees represented different functions and organizations. Interviewing people in different roles adds to the richness of the data, which was needed to make this study more multi-dimensional. Although McCracken (1988, p. 37) suggested that 8 interviews was a sufficient number, to gain robust insight and deeper understanding, participants from all actor firms were interviewed until the point of diminishing returns or saturation was reached.

Observations and documents provided by the organizations of the network have also been used as secondary data in the study. The study is non-participatory and overt in nature. The observations made can be broadly categorized as observations within the company premises (observing meetings and conference calls) and observations made at site (e.g., laying fiber-optic cable, installing VSAT, checking equipment). Atkinson and Coffey (2004, p. 267) also stressed the importance of documents prepared by the organizations. Therefore, certain minutes of meetings and reports were also used to support the analysis. Important data sources used were minutes of the meetings, presentations, brochures, emails, layout drawings, and worksheets. According to Atkinson and Coffey (2004, p. 276) such documents portray both the record keeping of an organization's internal reality and self-presentation to others.

For analyzing the data collected during this study, a modified form of grounded theory has been used, as this approach supports our understanding and description of the phenomenon based on the actor's subjective descriptions and interpretations of their experiences in context (Locke, 2001, p. 298; Charmaz, 2006). Grounded theory finds relevance in areas where the research is oriented towards developing context-based, process-oriented descriptions and explanations of the phenomenon (Orlikowski and Baroudi, 1991, p. 145). Grounded theory as a research strategy has been used under different research traditions given the differences in epistemological assumptions. In this research, however, we used the approach as adopted by the positivist researchers, which suggests that meaning inheres in the data and the researcher discovers it (Charmaz, 2006). Thus we believe that careful application of methods produces theoretical understanding.

5. The TAXNET Project Network

The Department of Income Tax (DIT), government of India, wanted to connect all its offices across the country. It has 752 offices across 510 cities supported by almost 50,000 employees, of which around 15,000 had to be provided connectivity. With the help of various experts, the DIT designed a project involving various requirements and offered it as a bid. The project was named the “All India Income Tax Network (TAXNET).” The objective of the project was to establish wide-area network (WAN) and local-area network (LAN) connectivity for all offices throughout India for DIT; implementation and maintenance requirements where included as part of the project. The project was meant to be completed in 8 months divided into 2 phases. The first phase of the project covered about 219 buildings in 60 cities, which required upgrading of the existing networks and maintenance for five years. The second phase required establishing connectivity in the remaining 533 buildings in 450 cities and maintenance for five years. The TAXNET project had to be implanted as a solution on turnkey using the virtual private network (VPN) protocol and state-of-art broadband technology.

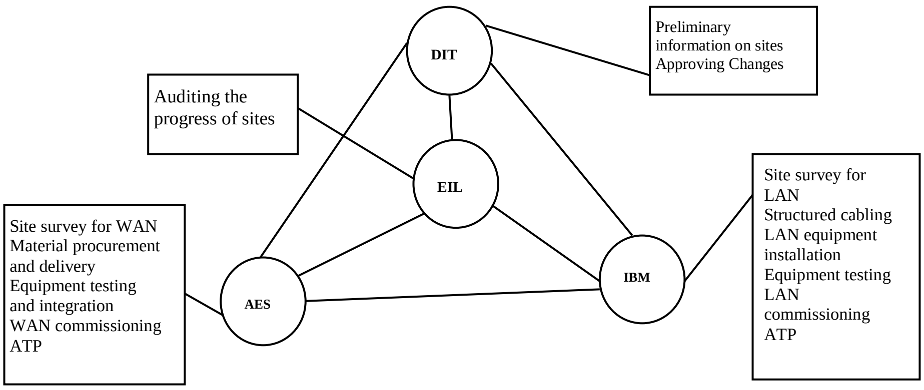
Among firms who made bids, Apex Enterprises Services (AES), a managed service provider, would provide WAN connectivity and a consortium partner, International Business Machines (IBM), would provide LAN connectivity. The DIT wanted the firms to address the complete requirements of the TAXNET (in terms of LAN and WAN) under one project rather than addressing these in a piecemeal manner. Thus, the project required a partnership to deliver various components of a whole, addressing these individually under the umbrella of a single consortium bid.

AES-IBM was required to provide/upgrade, install, commission, configure, implement, operate, maintain, and manage end-to-end connectivity from the National Computer Centre at Delhi to all DIT offices across the country. They were advised to conduct site surveys and assess the number of nodes to be connected. On the basis of this assessment, they were required to submit a LAN network design, which would be implemented after being approved by DIT.

The network solution had to be based on multi-protocol label switching IP-VPN platforms. End-to-end connectivity had to be provided in which the last mile links needed to be provided using leased terrestrial circuits, preferably optical fiber and VSATs providing the required bandwidth. VSAT-based networks using extended C band had to be planned for specific locations. An IP addressing scheme for the WAN and LAN had to be designed and reviewed by DIT before implementation. The solution had to offer connectivity and bandwidth for video conference facilities between the Central Board of Direct Taxes and the 48 offices of the Chief Commissioner of Income Tax located across the country. The proposed network architecture would also have a backup at the DIT disaster recovery site at Chennai. The site had to be adequately prepared for necessary facilities, such as electrical wiring for the communication equipment with suitable circuit breakers and electrical distribution boxes, termination of WAN links using termination modules, provision of telecom racks, uninterrupted power supply with sealed maintenance free VRLA batteries, air conditioning, fire detection and alarm, fire suppression equipment, and related requirements.

To oversee the entire implementation, DIT appointed another government agency—Engineers India Limited (EIL)—whose role was to act as the auditor to the entire project implementation. They were supposed to vet all the plans for project implementation which were submitted to DIT. They had to ensure that both network implementers adhered to the guidelines established for implementing the connectivity. These actors form subnet A of the project shown in Figure 2.

Figure 2. Actors in TAXNET Subnet A



The uniqueness of the proposal stemmed from the fact that DIT insisted upon the service providers bidding for the case in a build-own-operate model with clear guidelines on the expectations from the customer in terms of deliverables as well as the stipulation of certain minimum quality of access network necessitating substantial build-out from the bidders.

AES provided consummate telecom services provisioning expertise over multiple media/technology platforms as well as connectivity reach while IBM provided a comprehensive IT/Network/Applications systems integration, support and associated skill sets along with the leadership stature in the IT hardware sector to the combined entity. The complementary skill sets and proposed partnership from

AES and IBM led to a successful bid for the TAXNET project.

5.1 Knowledge Integration in the TAXNET Project Network

Surveys of sites by AES and IBM became an important intermediary step before taking up installation. The list of offices forwarded by DIT had been prepared in February 2006 and was subject to changes, e.g., vacating rented offices, shifting to new locations, or new IT offices being opened.

This changing list of offices impacted the total number of buildings to be networked in a region and the number of users in each building. For each change, a "change order" was given to AES and IBM, and the firms were allowed to begin site preparation and activity only once it had been approved and consolidated in the central plan.

Due to the time constraints, both AES and IBM subcontracted work to other actors. IBM evaluated GTL and TVS as partners to do site surveys and site preparation. AES used an authorized service provider for VSAT, and asked them to do the site survey for all 124 locations to be connected on VSAT. AES enlisted ALDS and ABTS to provide support for laying short- and long distance fiber. ALDS provides inter-city connectivity whereas ABTS provides intra-city connectivity.

Including subcontractors, the total number of actors involved in the network became 9. However, the interaction pattern among all the actors was not uniform. Apart from the actors of subnet A, who were in constant interaction with each other, the other actors showed specific patterns of interactions. For instance, ALDS and ABTS only interacted with AES; similarly, TVS and GTL only interacted with IBM. Thus, to simplify analysis, we identified 2 more subsets—subnets A1 and A2—to study interaction among the actors and identify knowledge integration. The actors belonging to these 2 subnets are shown in Figures 3 and 4.

5.2 Additional Knowledge Provided by DIT to Actors

The cities and towns which had to be connected were categorized into A1, A2, B1, B2, and C2 categories depending on the senior most officers in charge of each office, the number of users in each building, and the nature of primary and back-up link. Table 1 shows final classifications to determine connectivity requirements.

Figure 3. Actors in the TAXNET Subnet A1

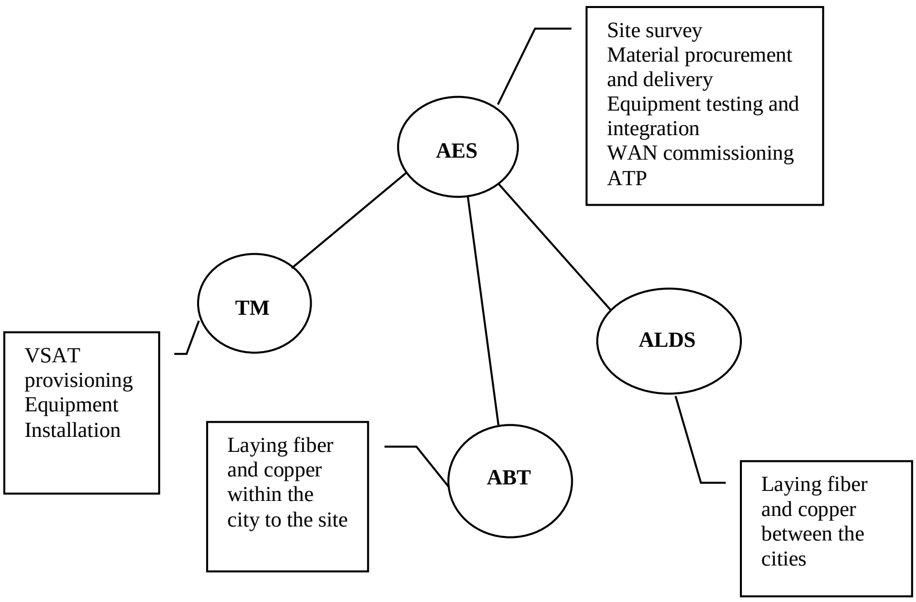


Figure 4. Actors in the TAXNET Subnet A2

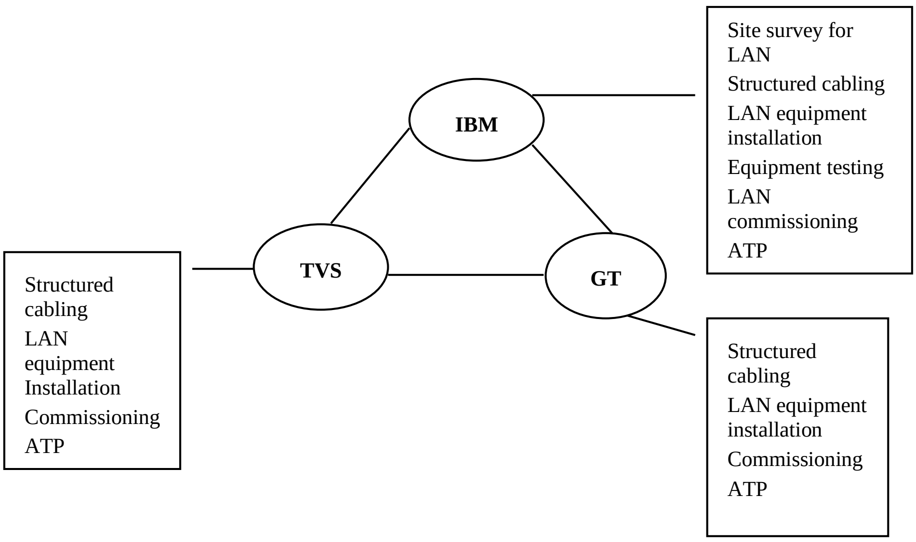


Table 1. Summary Classification of Buildings and Connectivity Requirements

City Classification	Number of cities	Senior most official in charge	Building category	Number of buildings	Primary link	Secondary link
A	108	CCIT/CIT	A1	142	Leased line on optic fiber	Leased line on optic fiber with route diversity
			A2	166	Leased line with optic fiber	ISDN
B	280	Addl. CIT/JCIT/D CIT/Asst. CIT/ITO (with more than 2 users)	B1	7	Leased line on optic fiber	Leased line on optic fiber with route diversity
			B2	306	Leased line on optic fiber/copper	ISDN
C	122	ITO (with 2 users)	C2	124	VSAT	—
Special Categories				6	Fiber	Leased line on optic fiber with route diversity
Total	510			752		

The classification system accounts for different requirements at various types of sites, such as a different bill of material and a different set of procedures for preparing sites. Thus AES and IBM, along with their vendors and subcontractors, started working out on detailing the project phases, sequencing the tasks, and preparing purchase orders.

6. Analysis and Discussion

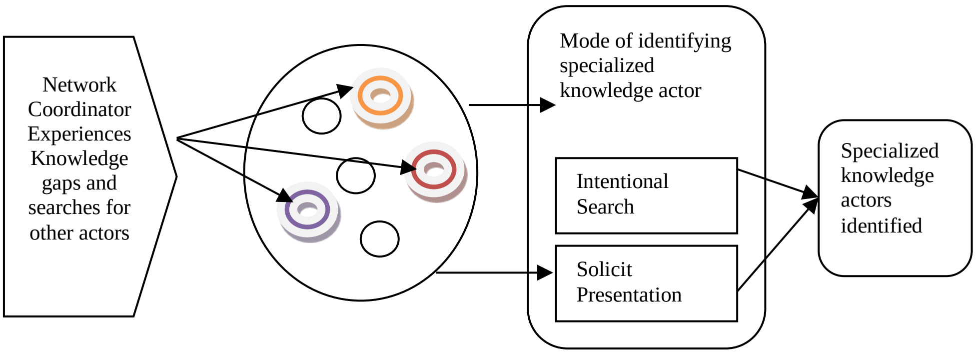
It has been established that organizations are units of specialized knowledge and often exhibit interdependencies in order to pursue ongoing organizational activities. Organizations thus integrate specialized knowledge to bridge knowledge gaps. However, KI is affected by issues resulting from social dilemmas and knowledge dilemmas or the combination of two (Cabrera and Cabrera, 2002, p. 693). To overcome these problems, organizations collaborate to form project networks.

However, challenges related to epistemological differences of knowledge, i.e., that knowledge can either be tacit or explicit, can be addressed only by conceptualizing other forms of knowledge such that KI is not just perceived as sharing and integration of best practices among the organizations.

Hence, in the TAXNET project, knowledge is been conceptualized as "what an individual has to know to be able to able to perform a task" (Mirabile, 1997, p. 74). This allows the focus to shift to an actionability aspect of knowledge which is easier to observe. The entire project network was studied by breaking it down into phases, sub-phases, activities, and tasks.

The actors in the TAXNET project are specialized knowledge actors and thus act as "knowledge identifiers" and discover other actors to bridge knowledge gaps by providing relevant knowledge. AES searched actively for knowledge actors to provide LAN connectivity. Though IBM did not initiate any search, it did not refrain from providing a response to AES. Thus AES, which is the knowledge seeker, solicited knowledge from source IBM, in a manner termed "intentional search" by Aguilar (1967, p. 74). This was also characterized by a high level of intrusiveness of the knowledge seeker and a low level of intrusiveness by the knowledge source. The process of identifying knowledge actors is shown in Figure 5.

Figure 5. Identifying Specialized Knowledge



However, it is interesting to note that, during this stage, both knowledge actors and "knowledge types," which determine the implementation and progress of the project, are being identified. Thus, in the TAXNET project, 3 types of knowledge can be clearly seen as determinants of the KI process. The first type of knowledge being used in the project pertains to the sites on which connectivity has to be established. This knowledge is present with DIT and has been passed on to AES and IBM. This is known as object-based knowledge (OBK) and it is the initiating point for all project planning and implementation schedules. This knowledge is also an important input for generating coordinating knowledge (discussed below). OBK is knowledge related to a certain object which is undergoing transformation; it is used to perform an activity on the project by various specialists using specialized knowledge (Christensen, 2007, p. 69). OBK may be applicable wherever the object (e.g., patient, customer, or machine) needs to be transformed. AES and IBM in turn pass on the OBK to their respective subnet knowledge actors. Table 2 shows the OBK generated for the TAXNET project.

Table 2. Object-Based Knowledge

Total number of sites	Mode of connectivity to be used for the sites	Information pertaining the sites

752 sites	306 sites to be connected using copper
	322 sites to be connected using fiber
	124 sites to be connected using VSAT
		• Address of each site
		• Details of the contact person
		• Size of the communication room
		• Number of users (nodes)
		• Category of sites
		• Ring architecture
		• Guidelines for establishing networks
		  o Future increase in number of nodes
		  o Placement of equipment
		  o Cabling and wiring norms to be followed
		• Earthing of equipment

However, this OBK is further refined and updated by the knowledge actors before planning further. Table 3 shows the updated OBK that is finally used in the TAXNET project.

The second category/type of knowledge comprises technical and professional knowledge existing with the actors—their experience, education and other qualifications, and training. This knowledge has been termed professional knowledge (PK). PK describes knowledge that enables a person to perform her job. A narrower version of this knowledge has also been referred to as know-how by Brown and Duguid (2000, p. 312), but in this study PK originates from the person's formal education and experience in performing the job. PK is a prerequisite for being able to contribute to organizational activities as a specialist, but it does not produce any organizational outcome (Christensen, 2007, p. 168). PK is usually particular to an organization because each organization possesses specialized knowledge, which is the sum of the expertise of those who work in the organization and is not available to other firms (Kay, 1993, p. 65). Such organizational knowledge is collective, above and beyond discrete pieces of information, and it is a pattern formed within and drawn upon by the organization over time. Thus, organizational knowledge is the capability that the members of an organization have developed to draw distinctions in the process of carrying out their work, in particular concrete contexts, by enacting sets of generalizations whose application depends on historically evolved collective understandings and experiences.

Table 3. Updated Object-Based Knowledge

Updated OBK	Basis for updating OBK
Location of the communication room	Industry best practice
Power supply in the communication room	The total power available to the building and power required for the equipment placed in the communication room (information gathered from the contact person and using experience to make a decision)
Place for earthing	A small open place either in front or the back of the building for creating an earth pit as per the industry standards (based on experience and actual ground reality)
Any kind of civil work to be done in the communication room	Rooms of size larger than 100 ft^2 have to be partitioned. Any repair pertaining to roof and floor has to be made (based on experience and training)
Number of nodes finalized	The current number of users and the expected number of new users over the next five years (based on experience and training)
Placement of main switch and sub switches for LAN network	Experience, training, and industry best practices
Any civil work required to be done for the VSAT sites	To counter any animal menace and to make roof top strong enough to hold the weight of equipment (based on experience and training)
Flow of LAN cabling	Experience, particular conditions, and industry standards
Entry and exit points for WAN media (fiber and copper cables)	Experience, training, and particular conditions

The third and the last category of knowledge required by the actors to perform their tasks is “who does what and when.” This is known as coordinating knowledge (CK) (Christensen, 2007, p. 168), and it was a commonly generated by the network implementers AES and IBM. CK is embedded in rules, standards, and routines for how tasks are supposed to be performed. CK guides the application of PK to transform an input into an output. The CK generated to implement the TAXNET project is shown in Table 4.

Table 4. Coordinating Knowledge

Actors	Elements of CK	Details
The coordinating knowledge was developed jointly by AES and IBM but used by the actors of subnet A1 and A2	Teams	Identifying members to assign responsibilities and territories
	Escalation Matrix	Channelize flow of communication among the actors
	Formats	Site survey format Site requirements format Site preparation format Site acceptance format
	Daily Updates	Excel worksheets updated continually by the MIS officer Emails among the team members Con-calls (conference calls daily to understand the progress and constraints) Phone calls
	Procedures	Established procedures for site surveys, site preparation, and site acceptance
	Meetings	Updating the top management of the respective organizations and DIT and EIL about progress and constraints

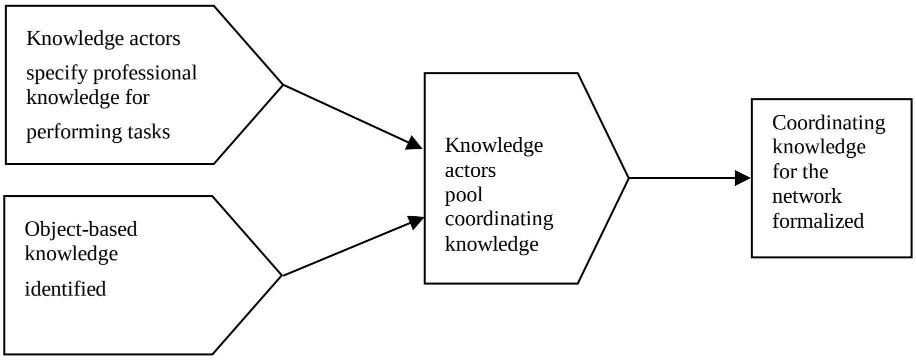
6.1 Acquiring Knowledge

After identifying actors (EIL, AES, and IBM), DIT, supplied them with necessary explicit knowledge to help them perform their tasks. This knowledge pertained to location of sites, number of nodes, category of sites, mode of WAN connectivity, size of communication rooms, and so on. This is OBK as identified earlier. OBK provides a basis on which actors define a system of coordination and CK in order to apply their PK. The "object" in this case is the site which cannot be transferred so all the information related to the object has been supplied to other actors by DIT. However, while AES and IBM use OBK to apply their PK, EIL is using OBK to finally audit the site.

Also, the OBK had to be updated by the network implementers on the basis of initial observations/diagnosis of the object (site). The updated OBK was again sent by DIT to all actors and formed the basis for final CK. The PK present with the actors is neither shared nor transferred around subnet A. On the other hand, OBK is transferred from DIT to other actors, which is being utilized to generate CK. The flow of OBK is thus unidirectional. CK, however, has multidirectional flow. CK is generated by actors of subnet A as they plan their courses of actions and plan resources accordingly. CK is generated based on the constraints imposed on them and resources available to them. It is explicated through formats for capturing information, such as an escalation matrix, though each organization has CK specific to its needs. In the case of TAXNET, a collaborative CK was developed by AES and

IBM and passed on to all actors in all subnets. CK is common to all the actors, but the flow is more frequent among AES and IBM. Thus, acquiring knowledge among actors is shown in Figure 6.

Figure 6. Generating Coordinating knowledge



6.2 Utilizing Knowledge

Knowledge utilization can be observed in a number of ways, including one-time application of knowledge, storing knowledge in archives or in people for possible repeat access, or ongoing application of knowledge.

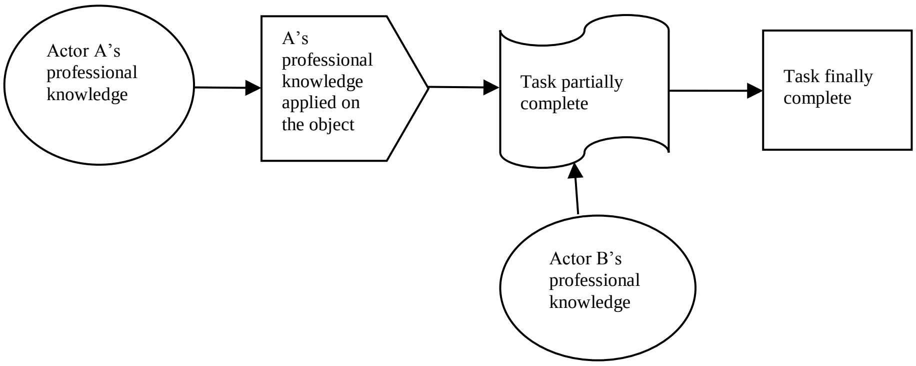
In the case of subnet A, DIT explicates OBK and disseminates it to other actors. All actors have PK that has to be applied on the site. Knowledge application and direction are the 2 modes by which knowledge utilization (KU) occurs in subnet A. The actors applying PK are technically qualified and have requisite experience to work on this project.

Interestingly, CK provides the basis upon which KU occurs. CK comprises various mechanisms designed on the basis of task dependency among the actors. Dependence is inevitable because of the specialized nature of knowledge possessed by each actor. The process of KU is shown in Figure 7.

6.3 Process of KI in Subnets A1 and A2

The firms of subnet A1 are AES, ALDS, ABTS, and TMS. Mainly due to limited time and wide spread of DIT offices, AES decided to invite more actors. Since AES was responsible for establishing WAN infrastructure, it required actors with specialized knowledge for WAN. It assigned ABTS to provide short-distance connectivity, ALDS to provide long-distance connectivity, and TMS to provide VSAT connectivity. AES conducted an intentional search for actors specializing in short- and long-distance fiber and copper laying and VSAT connectivity.

Figure 7. Knowledge Utilization



Though AES identified relevant knowledge actors, it did not seek transfer of PK from source to seeker. Rather it just ensures that actors applying their PK on the site as per the OBK passed on to them. Thus there is a unidirectional flow of OBK, but there is no flow of PK among the actors. Rather, application of PK is guided by the common CK generated among actors.

In subnet A2, IBM initiated a search for specialized actors to finish the project on time. However, in contrast with the knowledge search by AES, which searched for actors with different PK from its own, IBM searched for actors with the same PK as its own. IBM wanted to divide the sites among it and these actors so they could work simultaneously. IBM is thus a high intrusive seeker of knowledge (Choo, 2001) and made intentional search for knowledge source. The actors of subnet A2 possess the same PK, hence it is not transferred among them. The actors initially updated OBK, and on that basis they applied their PK.

6.4 Project Outcomes

One of the major outcomes of the TAXNET project is the satisfaction perceived by the actors involved in the network. Each actor expressed satisfaction in terms of results achieved by it. For instance, DIT officials were satisfied with the functioning of the sites and appreciated the efforts of other network actors. AES and IBM expressed satisfaction over implementation of the project. Other actors like TMS, ALDS, ABTS, GTL, and TVS felt that they could contribute to a major project in a timely fashion and recounted it as a great learning experience.

Table 5. Cross-Subnet Comparison

	Knowledge identification	Knowledge acquisition	Knowledge utilization
Subnet A	Intentional search by the knowledge seeker Bids solicited from the knowledge source Only professional knowledge required	No effort made by the knowledge seeker to acquire professional knowledge from the knowledge source Object-based knowledge supplied by the knowledge seeker to the source	Knowledge source applies professional knowledge on the object
Subnet A1	Intentional search by the knowledge seeker Knowledge source identified on the basis of network transactive memory system	No effort made by the knowledge seeker to acquire professional knowledge from the knowledge source Object based knowledge verified and updated Updated object-based knowledge supplied to the knowledge source	Knowledge source applies professional knowledge on the object
Subnet A2	Intentional search by the knowledge seeker Presentations solicited by the source	No effort made by the knowledge seeker to acquire professional knowledge from the knowledge source Object-based knowledge verified and updated by both the knowledge seeker as well as the source.	Knowledge source applies professional knowledge on the object

6.6 Discussion

During the interviews, though each member expressed the objective of the network in his/her own words, one could see that the need to connect all offices of the IT departments across the country had been stressed, which is the sum of the shared perception of the members' goals (Enberg et al., 2006, p. 43). The aim of the project network is a useful indicator of what type of knowledge is required to perform the activities. Some authors suggest that identifying the knowledge gap is important in a project network. Then, in the process of moving from the existing knowledge base to the target knowledge base, it may be necessary to transform and redistribute knowledge that is already within the team, acquire knowledge from outside the organization, or invent new knowledge (Hall and Andraini, 2002, p 104; Koskinen, 2004). The TAXNET project required three types of knowledge shown in Table 6.

Table 6. Knowledge Types and Status

Knowledge type	Status
Professional knowledge	Existing and present with the actors
Coordinating knowledge	Generated by the actors
Object-based knowledge	Acquired by the actors

Since the knowledge is specialized and distributed among the members of the organization, the team members also rely on the TMS of the network to locate the required knowledge and pool it to accomplish the collective task (Alavi and Tiwana, 2002, p. 213). Also, in case of a project network, the actors possess specialized knowledge and search for potential actors to fill in knowledge gaps by supplying the necessary knowledge (Huang and Newell, 2003, p. 165).

Primarily, DIT, AES, and IBM engaged in searches to identify knowledge actors. Table 7 summarizes the knowledge gap analysis.

Table 7. Summary of Knowledge Seeker and Source

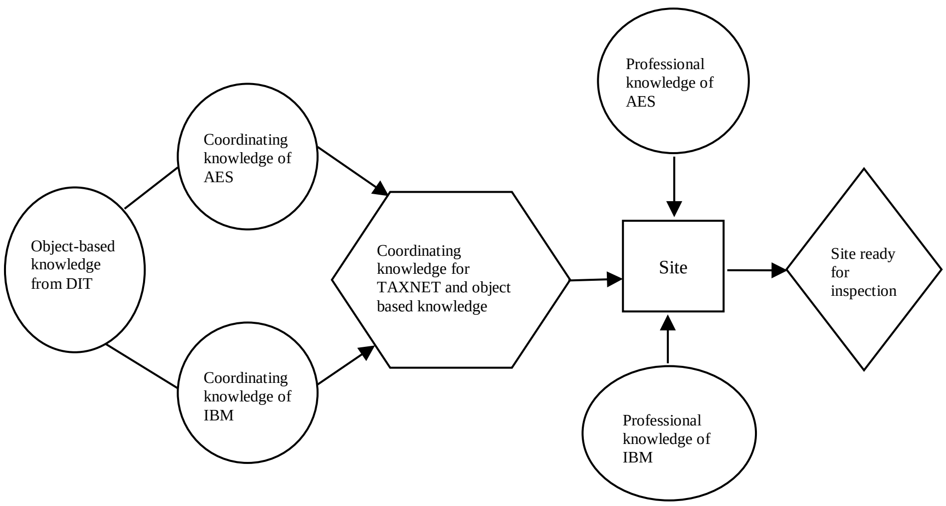
Knowledge seeker	Knowledge gap	Knowledge source
DIT	WAN and LAN connectivity	AES for WAN connectivity IBM for LAN connectivity
AES	Connectivity through VSAT Connectivity on fiber and copper cables	TMS for connectivity through VSAT ALDS and ABTS for laying inter-city and intra-city fiber and copper cable
IBM	Professional knowledge of LAN connectivity	GTL and TVS for providing LAN connectivity

All the knowledge seekers exhibited intrusiveness in terms of searching for the relevant knowledge source and were thus engaged in intentional searches for the knowledge sources. The actors of subnet A understand the knowledge inputs required to implement the project, but each of them is specialized to provide specific knowledge input. It is interesting that each actor is specialized in a distinct knowledge pertaining to its activities. Though the actors may have an understanding of the knowledge possessed by the others, they are only involved in completing a distinct phase in the implementation of the entire project. According to the conceptual model developed earlier, after having identified the relevant knowledge sources, the knowledge seeker would acquire the relevant knowledge from the source by transferring written documents, physical objects, or persons; by acquiring training; or by cooperating with others. However, the actors are not acquiring all types of knowledge from each other but rather only OBK. Thus, knowledge identification is an important step in the process of KI as it identifies (i) all the relevant actors for the network, (ii) which actors possesses OBK—the only knowledge that needs to be shared among the actors, (iii) PK among the actors, which provides the basis upon which CK is generated by the actors. Since CK guides which actors do what and when, it basically guides the application of PK on the object. It is interesting to note that once actors having PK are identified, the knowledge seeker makes no attempt to acquire it but rather simply ensures that the knowledge source is applying its specialized knowledge on the object directly and as per the CK. Thus after identifying specialized PK, the actors coordinate their respective knowledge to be applied. The knowledge seeker does not perceive the need of acquiring PK from the source as it trusts the knowledge source to apply its knowledge on the object as and when required. Studies have shown that this type of trust plays an important role in improving the effectiveness of transfer and acquisition of knowledge among actors or individuals (Politis, 2003, p. 76). The actors apply knowledge using direction and routinization.

In this network, certain actors, e.g., ABTS and ALDS, applied PK involving actions they undertake on a routine basis. Routine is considered to be a subprocess in the KU stage and is understood as a set of activities routinized to the extent that choice has been simplified by the development of a fixed response to defend stimuli (March and Simon, 1958, p. 134; Grant, 1996). On the other hand, other actors, e.g., TMS, TVS, and GTL, adopted direction and application as the methods of KU.

However, since tasks have to be performed sequentially, there is an inherent dependency among the actors which guides the generation of CK. Knowledge application is captured in the TAXNET project in Figure 8. In spite of inherent dependency, no two actors are involved in simultaneous knowledge application.

Figure 8. Knowledge Utilization



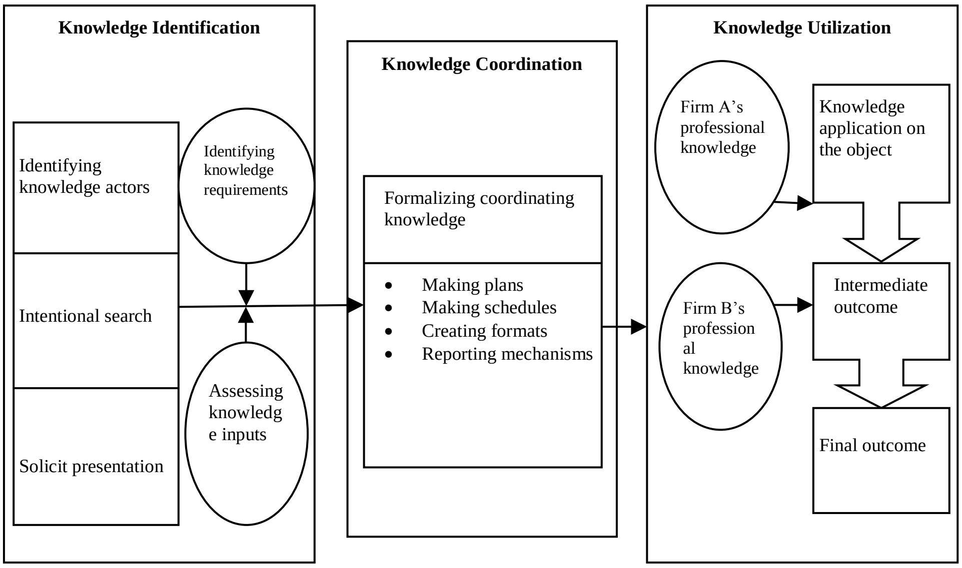
7. Conclusion

KI has been known to be a complex phenomenon (Lampel and Jha, 2008, p. 54) mainly because (1) integration depends on specialized disparate bodies of knowledge and (2) it is uncertain as under most circumstances knowledge cannot be separated from human beings and social settings in which it is embedded. Thus, there is a need to identify, acquire, and use different types of knowledge to achieve an outcome (Collins, 1993; Blacker, 1995, p. 1027; Lampel and Jha, 2008, p. 89); and different actors must be selected and organized in order for KI to be successfully accomplished (Liebeskind et al., 1996, p. 434; O'Mahony and Bechky 2006, p. 435). However, as evident from the process of KI in a project network context, knowledge identification is an extremely important stage. This is because project networks which are formed for the purpose of accomplishing large projects require actors having specialized knowledge which are more often than not quite dispersed. Thus, to accomplish project objectives, it is necessary to identify suitable actors, not only for specific tasks but also for network compatibility and network mission (Faraj and Sproull, 2000, p. 1560). Also, actors integrating knowledge in project networks may be willing to sacrifice some of their specialized resources by allowing them to be used in other project activities undertaken by the network. This is similar to the case in industries when specialized knowledge cannot be attached to the organization on a permanent basis, either because it is very costly or because anticipating the demand for specialized resources is next to impossible. Project networks which exhibit such characteristics are those formed in engineering, construction, establishing large information systems, and films (Lampel and Jha, 2008, p. 76). These conditions also obviate the need among the knowledge seekers to acquire knowledge from the source and then apply it. This perspective is supported by authors noting that cases a task requires multiple resources also demand efficient resource scheduling to avoid deadlock and starving (Crowston and Myers, 2004, p. 8). Hence, the actors need to identify the knowledge required to complete the task based on the specialization of the actors in the project network. Specialization of knowledge among the actors serves as criteria for network membership and generating a schedule to facilitate implementation of the task (Malone et al., 2004, p. 39). Based on this discussion, it emerges that in a project network KI stages are distinctly different from the one proposed by various authors. A modified model of KI is shown in Figure 9.

7.1 Directions for Future Research

Due to overwhelming time and resource constraints, this study was carried out on a single project network; however, it would be beneficial to draw comparison by selecting at least two projects for study. Moreover, comparing a non-project-based network environment with a project-based environment can throw open an entire gamut for future research.

Figure 9. Knowledge Integration in a Project Network



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