Know-Who Based Innovation Networks: For Cross-Level Breakthroughs

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Abstract

The overall purpose of this paper is to enhance our understanding of how innovation can be managed across different networks and at different levels of analysis based on know who, i.e., better knowledge of who knows what in strategically relevant areas of knowledge. We address recent innovation literature and link this to a more extensive review of leading networking theories for new combinations across these disciplines. An abductive research method is applied based on iteration between an in-depth case study of a sports car manufacturer, and the development of a theoretical framework, to help us better analyze and understand how breakthrough innovation depends on human interaction across different types and levels of networks.

Our research findings are that the stage of profiting from networked innovation is mainly a result of having openness and building human bridges across the entire process of innovation, but to manage the openness through different network structures depending on whether the focus is on exploration, or on exploitation. By managing these different network structures, a company does not only have an open policy to the exploration phase, but can be partially open in the exploitation phase to allow for other companies to profit from its own innovation efforts, while getting licensing income in return.

As a main contribution of our paper, the human bridges and links are integrated into a new management approach that supports the transformation of science into sales – using know-who based networks to manage the transition from knowledge creation to business implementation. This approach can enhance a company's ability to capture synergies between external research and corporate technology innovation and thereby balance exploration and exploitation for faster commercialization of breakthrough innovation.

Keywords: Know-Who, Networked Innovation, Innovation Networks, Exploration, Exploitation.

How Time-Based Competition Sparked Know Who Based Innovation Networks

As stated by Fowles and Clark (2005, 46) 'corporations are now in an ideas-to-market race, in which many of the best and most innovative products and services (and their inspirations) come from new and varied sources'. Time-based competition in innovation received particular attention in Japan in the 1980s and the early 90s (Abegglen and Stalk, 1985; Stalk and Hout, 1990). This is also where our research started with more than 150 interviews conducted during the mid-90s and additional follow-up interviews in early 2000 to better understand how Canon, Sony and Toyota manage to reduce time in their innovation processes (Harryson, 1997; 2005).

Reflections on the highly relationship-driven approach of Sony and other Japanese companies led to conclusions like (Harryson 1996, p. 37) 'ultimately, the knowledge-creating R&D process is no longer limited to individual know-how, but draws instead on know-who – and unlimited global sources of invention that continually nurture internal learning and improve R&D performance'. George Stalk (1998, p. xiii) endorsed the concept through his argument that 'moving from *know-how* to *know-who* is not just a powerful tool to increase innovation capacity, it is the *sine qua non* to manage the continuously increasing complexity of most industries'.

Whereas know-how is the ability to solve problems efficiently based primarily on internally accumulated knowledge, experience, and skills, know-who is the ability to acquire, transform, and apply that know-how through personal relationships (Harryson, 1996; 1998). The 'who' in know-who based companies knows who has the know-how, has the active empathy to rapidly establish the trustful relationship required to acquire that know-how, and has the multiple competencies required to transform and apply it in a new context so that innovation can occur. Lundvall (1998, p. 417) confirms that know-who 'involves the social capability to cooperate and communicate with different kinds of people and experts'. Hedberg et al. (2000) introduce the value-star as a complement to Porters' value-chain and uses the analogy of a know-who based company acting as node in a network of know-how required to cerate new knowledge and customer value. Uzzi and Dunlap (2005, p. 60) stress the importance of trust, diversity and brokerage to build know-who:

> Research shows that if you create your networks with trust, diversity and brokerage, you can raise your level of information from what you know to who you know.

The perhaps most important element of the know-who based approach resides in the unique synergy that can be obtained between external and internal networking (Harryson 1998; 2002). Indeed, the greater openness to external technologies and skills – acquired through primary contacts linked to nonredundant networks (Burt, 1992; 1993) – reduces the need for internal specialization in narrow areas. Instead, a new breed of multicompetent innovation agents can be developed with strong ties among the project network members based on past joint-experience and a certain degree of information redundancy for rapid transformation of tacit knowledge. Their focus on networking and relationship-ability makes them better equipped to acquire, transfer and transform also the tacit dimension of knowledge. Know-who based companies selectively transform certain weak ties into stronger ones to individual, organizational and inter-organizational strategic partners who become deeply involved in the exploitation of radical innovation. In this sense, the balancing act from exploration to exploitation can also be seen as an act of transformation from relatively open to more closed networks – interconnected by project networks consisting of multicompetent engineers and marketeers.

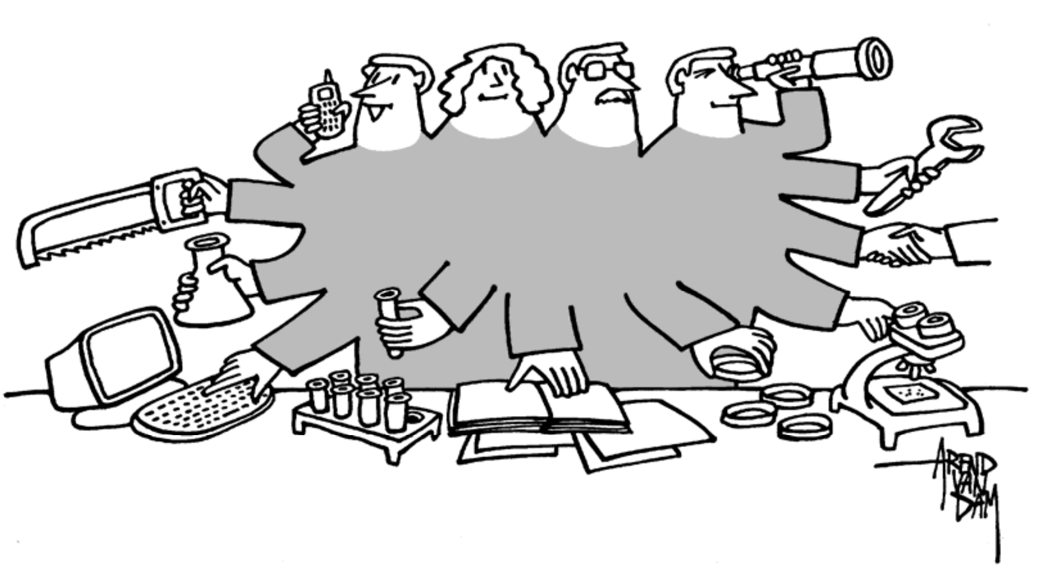

Figure 1: Multicompetent Engineers and Marketeers Building Know Who Based Innovation Networks

The concept of using more external collaboration is at least as old as the concept of open innovation itself. Nyström (1990) introduced the term *open company development strategy* to emphasize that companies can achieve a greater innovative potential by opening up to external collaboration and broadening their internal base of technologies, skills and competences. Pisano (1990; 1991) noted how established companies and newcomers can co-exist in a sort of symbiotic supplier-buyer relationship. This phenomenon is particularly obvious when established firms realize a lack of relevant technological skills to compete with certain new entrants, and take corrective action by establishing collaborative links with other external entrepreneurial firms to access their specialized R&D assets. This strategy allows the incumbent to maintain an internal focus on domains where it has developed a distinctive competence (e.g. commercialization). According to Quinn (2000), the reason why many companies are outsourcing innovation is that it calls for such complex knowledge that only a broad network of specialists can offer.

Rigby and Zook (2002, p. 82) introduced the concept of *open-market innovation* as 'an approach that uses tools such as licensing, joint ventures, and strategic alliances to bring the benefits of free trade to the flow of new ideas'. Mohan Sawhney (2002, p. 26) may have been first in using the specific term: *open Innovation* – giving it the following definition:

> One of the basic principles of Open Innovation is "not all the smart people work for you." In this landscape of "enhanced knowledge," the innovation challenge has become how best to identify and use the knowledge that's available both within and outside the company.

This definition is echoed by Wolpert (2002) who argues that internally run initiatives must to a greater extent tap the potential of ideas, resources and capabilities of other companies, without loosing control over proprietary corporate secrets. Later, Chesbrough (2003a, 2003b) joins the open innovation debate and commercializes the term more widely. In short, the concept of open innovation implies that companies can attain competitive advantage both by leveraging the inventions and the ideas of other market players (that are relevant to the core business) to commercial ends as well as by licensing their own proprietary technologies (that otherwise would not have been exploited to the same extent) to external partners, who have different avenues of commercialization. This leads to the formation of new innovation networks (Simmie, 1997) and networked innovation, which Hellström and Malmquist (2000, pp.181-182) defend as follows:

> The underpinning assumptions behind the idea of Networked Innovation are that entrepreneurial teams, which combine different personalities, knowledges, skills and backgrounds, are more likely to accomplish an innovation than a homogeneous team.

That innovation is based on networks is a natural consequence of the fact that 'no business is an island' (Håkansson and Snehota, 1989). Sophisticated networks support creation and application of knowledge from scientific exploration all the way through to industrial exploitation in the factory complex whereby social interaction between individuals, groups and surrounding societal institutions, e.g. universities, is fundamental to the corporate knowledge creation process (Jansson, 2006). To capture and describe actors' knowledge, cognitive learning theories are adopted and the terms cognitive structure and meaning structures are used interchangeably (Eden, 1992; Dixon, 1994; Hellgren and Löwstedt, 1977; Timlon, 2006). Knowledge creating processes are regarded as organizational learning processes (Crossan and Berdrow, 2003; Holmqvist, 2002, 2003; Holmqvist and Larsson, 2004). In view of this, numerous authors (Aldrich and Whetten, 1981; Bartlett and Ghoshal, 1989; Easton, 1992; Håkansson and Ford, 2002; Håkansson and Henders, 1992; Håkansson and Laage-Hellman, 1984; Jansson *et al.,* (1990; 1995); Harryson (1998; 2006) have adopted a network perspective in which relationships and linkage patterns constitute the core element of analysis. Some general elements of our network perspective are:

- Networks typically emerge because no organisation is self-sufficient, but rather dependent on extra-organisational resources for its sustained competitiveness.
- A network perspective aims at understanding the totality of relationships and how they jointly accomplish the result.
- Networks can be divided into different (sub-) levels so as to better concentrate the level of analysis to a specific phenomenon where the main-activities happen at that specific level of the network.

Using a Network Perspective to Analyze Know-Who Based Innovation Networks

Håkansson (1987; 1989; 1990) considers how companies handle their technological development in relation to external clients and organizations, particularly in terms of collaborative projects, claiming that the question is not how the company manages its technological development *per se*, but 'how it manages to relate its technological development to what is happening inside and between other organizations' (1990, p. 371). In line with the essence of holism, the right combination of technologies and skills often yields a whole that is greater than the sum of its parts. Accordingly, it is essential to know where these parts are and, more essential still, to *know who* can best contribute to their transfer and transformation, and integrate the parts into a greater whole (Haryson, 1996; 1998; Uzzi and Dunlap, 2005).

While the transaction cost perspective takes transactions as given, instead of considering their creation, and stresses the efficiency benefits from reducing the governance cost of a transaction, a network perspective allows consideration of the strategic benefits from optimizing not just a single relationship but the firm's entire network of relationships, or know-who (Dyer and Nobeoka, 2000; Harryson, 1996; 2000). Indeed, a firm's alliance formation capabilities and the resulting networks can be thought of as creating inimitable and non-substitutable value as inimitable resources by themselves, and as a means to access further inimitable resources and capabilities (Gulati et al., 2000; Powell et al., 1996; Van Wijk et al., 2004).

The Know-Who Based Approach to Entrepreneurship

Know-who based innovation networks aim at identifying the essential parts that contribute both to creation and exploitation of innovation. In this context, three interrelated levels with different foci can be outlined:

1. Extracorporate *creativity networks* as primary sources of creating new knowledge and emerging technologies.
2. Intracorporate *process networks* for more effective transformation of invention into innovation – across the key functions R&D, design & manufacturing (D&M), marketing & sales (M&S) and product management.
3. *Project networks* interlinking and combining the different (opposing) characteristics and benefits of the aforementioned creativity networks and process networks.

For reasons outlined in detail in previous research (Harryson, 1998; 2000; 2006), creativity networks tend to be small by size and are usually self-managed in an organic fashion. By contrast, process networks are large in size and, therefore, typically managed by hierarchy in a mechanistic structure. As suggested by Figure 2, project networks are central in interlinking both exploration and exploitation so as to span the organizational chasm between creativity networks and process networks. The main argument developed in this paper is that only human networks, based on multicompetent relationship managers with extensive know who, can bridge the organizational chasm.

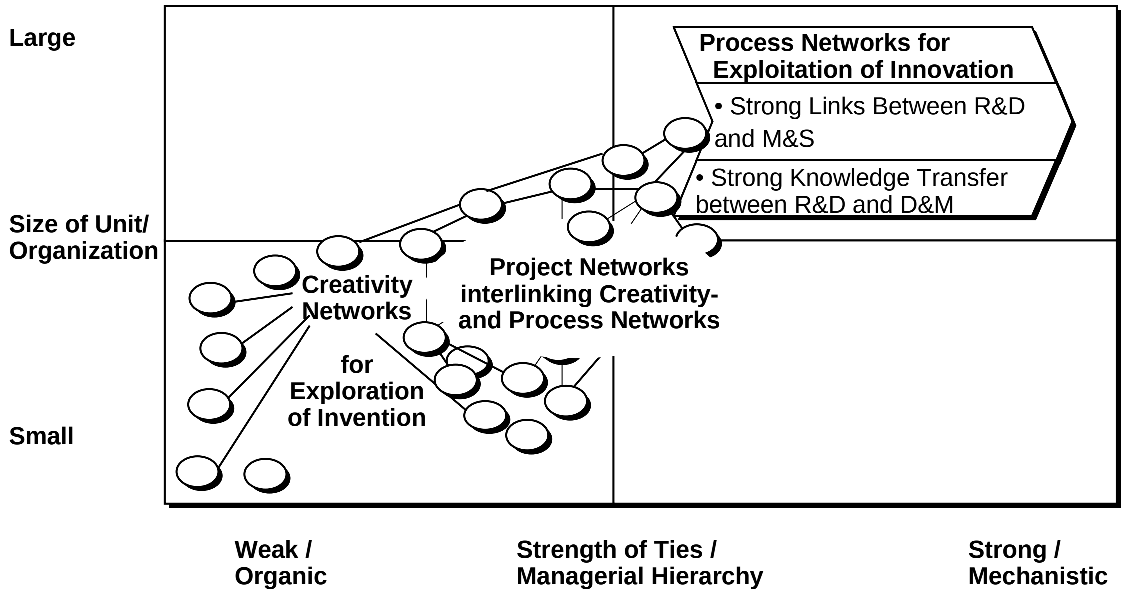

Figure 2 **Using Project Networks to Interlink Creativity- and Process Networks**

Research method

The methodological strategy behind this research is mainly abductive, being a mix of deduction and induction (Alvesson and Sköldberg, 1994; Jansson et al., 1995; Dubois and Gadde, 2002). This qualitative method rests on the limited possibilities of generalization of various theories in time and space. The purpose is theoretical development with a final stage of theory validation rather than theory generation based on grounded theory approaches (Glaser and Strauss, 1967). The empirical support of a theory is continuously assessed, or, inversely, a reality's theoretical support is investigated through the matching of theories with realities. Such a process either has a deductive or an inductive starting-point. The deductively angled processes are theory-driven, while inductive approaches are characterized by the continuous abstraction of empirical realities. This process has started from a more preliminary frame of reference, using the case-study approach (e.g., Merriam, 1998; Yin, 2003). The framework has been continuously refined through changing perspectives between deductive and inductive approaches. The final aim is to create a solid theoretical and empirical base, while at the same time strengthening the practical validation of the research by making the results relevant for organizations and society. The theoretical model presented in the article draws from earlier work including two doctoral dissertations (Harryson, 1998; 2000). There has been a continuous interchange between empirical data and theory, as empirical findings initiated the search for further theories. Internal validity concern has been addressed through the use of multiple sources for the case study in terms of number of interviewees and their positions in the organizations. Complementary information has been gathered from corporate publications and from other literature. By having key informants review the case report in several iterations, the issue of construct validity and reliability have been addressed as well.

Now that a first part of the theoretical framework as well as our methodology have been introduced, we can take a break from theory – at least temporarily – and instead explore a case example of how a small know who based company competed with a ten times larger and far more internally know how driven company to be first in commercializing a new innovation.

Give Me a Brake

Two well-known car manufacturers – Fastcar and Solidcar – were competing against time to bring out the first ceramic brake system into the market of commercial vehicles. In the late 1990s, the CEO of Fastcar was well aware of their know-how disadvantage: They had started their research efforts in this field much later than Solidcar, and had less than one tenth the number of researchers in-house. Still, the CEO ordered his relatively small engineering team to give him a ceramic brake system by 2002.
So far, ceramic brakes had only been used in racing car and aerospace applications, based on so-called carbon-carbon composites, which only last one race because of the active carbon fiber surface being oxidized due to the extremely elevated temperatures. For example, a formula one (F1) car approximately needs 120 brake discs for one season, at an average cost of $1200 each. As a compensation for the high cost, the main advantages of carbon-carbon discs are maintained brake performance during elevated temperatures, higher brake performance than conventional brake systems and weight reduction. Still, these advantages would not make up for the huge disadvantage of changing discs every 1000 kilometers if applied to an ordinary car. The American F16 Fighters were using ceramic brake systems with much higher longevity than the F1 applications, but the very special Ceramics Silicon Carbide solution was top confidential and neither accessible to Fastcar, nor to Solidcar. Fastcar's intention was to commercialize a ceramic brake system that lasted 300 000 km and could withstand temperatures above 1000 ºC without being oxidized and still maintain the same brake performance as F1 brakes. This can be compared to a high performance iron brake disc that typically lasts 60 000 km and can withstand temperatures of 700 ºC.

Spinning a Network of Global Know-How

For obvious reasons, the few material researchers of Fastcar were not focused on internal exploratory research, but on global networking and technology intelligence to identify and bring together the most relevant external sources of know-how in this area. Spiderman – the Head of Fastcar Brake Systems Engineering – had developed state of the art brake systems for more than thirty years. Now, he was very motivated to pick up the challenge of revolutionizing his industry by introducing a long lasting ceramic brake system for Fastcar's commercial vehicles so as to secure continued innovation leadership in this critical area.
Through his many years of experience within Fastcar's Motorsport Division, Spiderman had established a strong network of contacts within the world of academic research on ceramic and composite materials. He selected two academic research institutes and gave them one year each to explore and consolidate decades of research in the related areas and develop a specific compound based on ceramics and very special carbon fiber. He also had a research collaboration with Deutsches Zentrum für Luft- und Raumfahrt (DLR), which resulted in a couple of strategic patents – now exclusively owned by Fastcar. In addition, Fastcar had five experienced manufacturing process-chain and quality management experts with great system understanding, who dedicated significant time to the project.
Traditionally, Brembo in Italy was the partner of choice in Fastcar's break systems, but as Brembo also worked with important competitors including Solidcar, Fastcar started to look for another development partner for this specific project. Spiderman identified a company that did not have any experience in automotive components, but had absolute world-class competence in carbon ceramics for aerospace and industrial applications. More important still, this company also had a strategic partnership with the American aerospace composite company that was the owner of the proprietary surface treatment technology used for the F16 fighters.
Spiderman now had spun a forceful network consisting of one specialized supplier for ceramic materials to produce the actual disc, and two suppliers to develop the calipers and other critical components required to assemble a complete brake system. The perhaps most challenging requirement for this new break-disc amalgamation was to maintain the required structural properties at temperatures exceeding 1000 degrees centigrade – in addition to the longevity requirement of 300 000 kilometers of normal use. The first prototypes of the new ceramic discs worked only until temperatures of 650 degrees, after which some of the carbon material evaporated and the disc was oxidized. Further material exploration was called for so as to optimize the organization of the silicon carbide in the disc and reduce or prevent oxidation of its active surface. To solve this and related manufacturing problems further networking was required. Spiderman, who had already brought in a dozen academic researchers from the two domestic institutes, now made a more extensive networking effort.

Spiderman also made visits to the American aerospace composite company to learn about their surface treatment know-how, which he brought back to his own network of engineers in Germany.
In addition, Spiderman organized regular conferences to which he invited leading research institutes and experts from the whole world so as to bring their brainpower into a collective knowledge-creation process. Through these forms of networking, he identified Mr. Brainpower, who was a leading expert from Solidcar with ten years of related research experience. Mr. Brainpower was convinced to join the new supplier of ceramic discs – so as to strengthen Fastcar's own knowledge network in ceramic brakes at the cost of Solidcar.

Fastcar funded the research made by the academic partners to secure exclusive patent-ownership of the unique geometry that was developed. Fastcar also performed all quality control of the new components. This was made in the new center, which counted a total of thirty people of which less than ten were regular Fastcar employees. The quality control was a particularly important aspect with respect to product liability issues. Here, Fastcar's thirty years of experience in designing highly competitive break systems added significant value to the collaborative network. As the new disc manufacturing partner did not have any prior know-how in automotive parts, Fastcar had to invest several thousand man hours in knowledge transfer activities to add this critical know-how to their new supplier of the revolutionary ceramic disc.

Money Talks – Relationships Convince

In spite of the intensive activities, Fastcar was not first to market. Solidcar actually sold one car with a ceramic brake system that was mainly an internal development. Due to quality problems, this system had to be pulled back and was never further exploited in the market. The disc literally fell into pieces and Solidcar wanted revenge for ending up on a loosing track. They gave one of their agents, Mr. Moneytalks, a big amount of money in cash and ordered him to approach the few suppliers that had enough competence and experience to develop break pads for ceramic disks. This was the missing link for Fastcar so by making it impossible to access the missing link, Solidcar thought they would block the whole breakthrough. However, Solidcar underestimated the importance of strong social relationships in the context of innovation. Through his many years of experience in the business of break systems for racing cars, Spiderman had a very strong personal relationship to Mr. Grandissimo, who was the owner of a break pad company that specialized in F1 racing. Although Mr. Grandissimo was approached by Mr. Moneytalks, he declined the generous offer and preferred to deliver the desperately needed break pads to Spiderman. His decision may not have led to optimized financial rewards in this particular case, but Mr. Grandissimo valued his personal relationship to Spiderman more than some extra cash in the pocket. Moreover, he wanted be part of a revolution in the commercial automotive industry – rather than being part of blocking it.
Through the extensive networking and mobilization of leading know-how from several countries and continents, the project network of Fastcar identified a revolutionary ceramic break system solution. To achieve the goal, a technology to prevent the oxidation of the carbon fiber had to be developed. The extended network created the unique solution of applying a silicon carbide matrix to the carbon fiber, which generated a carbon ceramic(C/SiC). The resulting product featured both better durability and safety.

The new discs – commercially available since 2002 – offer higher performance during heavy workloads both in dry and wet environments. The actual weight reduction of 60 per cent, which is about 5 kg per wheel, has a significant impact on road handling since it affects fully unsuspended weight. Ceramic composite brake discs also offer the advantage of zero corrosion and shorter braking distance. Fastcar holds the full patent for the geometry, but maintained only two years of exclusive rights to commercialize the system so as to capture both licensing revenues and better scale-economies in manufacturing. Two leading car manufacturers are already licensing the new technology from Fastcar to apply it to their high-performance models. In this way, the networking strategy resulted both in brand enhancing patent protected innovation leadership and in additional revenues. Through extensive internal networking, the new composite material could also be transferred and applied to a revolutionary clutch system.

Knowing who has the know-how, defining new access points to this know-how and converting it into new innovation networks created a new breakthrough. This was an incredible act of strategic networking that knocked out competition.

Knockout Networking Lessons

The give me a brake case makes an interesting illustration of know-who based innovation networks from which we can distil several important lessons in terms of networking. Let us start by bringing the case into our theoretical framework: Fastcar clearly recognizes a need to leverage external brainpower for exploration of innovation, i.e., for creative research and discovery. For this purpose, Spiderman establishes contacts to so-called creativity networks. The creativity network is mainly an open and loosely coupled arms-length network encompassing primarily weak ties to selected external scientists and experts. The purpose of the creativity network is to create new scientific knowledge that can be transformed into commercialized innovation by a project network.

The purpose of a project network is to manage the balancing act between exploration and exploitation so as to secure breakthrough innovation. Spiderman builds a project network that involves two academic centers of brainpower and a large number of leading experts who secure the initial knowledge creation required to define the ceramic material. However, defining a material is still far from pursuing a full innovation cycle. This is why a process network was required to secure development and manufacturing of the ceramic material in the desired shape of a disc. Spiderman identified a specialized supplier with deep expertise in ceramic materials, but no expertise in making break discs. This illustrates a so-called diagonal pattern of interaction, or a cross-level collaboration. Spiderman is an individual who, in this case, collaborates with an organization – as opposed to a horizontal unit-unit, or individual-individual relationship.

As a company, Fastcar has innovated both the processes and business models for absorption of external technologies and skills and places very strong emphasis on social ties. For example, the social ties between Spiderman and Mr. Grandissimo were stronger than the financial offer by Solidcar and hence prevented a competitor from blocking out Fastcar from a strategic supplier of ceramic brake pads. The relationship-dimension of Fastcar suggests that a dominance of weak ties is beneficial for exploration in open creativity networks, and a dominance of strong ties is required for exploitation in more closed process networks. In network terms, the process network is therefore closed, tightly coupled, and hierarchical. The creativity network is the complete opposite with a relatively open structure. It contains both individual and organizational levels. As illustrated by the case, the creativity networks are mainly social networks, driven by personal relationships. Selected individuals at the universities are more important than the universities themselves. Accordingly, the social networks are dominating the organizational networks and act mainly as antecedents of organizational networks. The project network is a mix of creativity- and process networks, being semi-open at the beginning and more closed during the exploitation phase, when bridging the two opposing networks.

The case also illustrates how a typical breakthrough innovation evolution starts with a dominance of creativity networks to mobilize the required expertise to develop a revolutionary concept. The evolution continues by linking the exploration-oriented creativity networks to exploitation-oriented process networks to manage the conversion from knowledge creation to business implementation for breakthrough innovation to happen. The process network-dominance in the exploitation phase was witnessed by Fastcar's integration of the best individuals from the creativity networks into the process network at Fastcar's premises where most actors involved finally ended up.

Now, we can link our practical findings to networking structure:

The Process Network as Hierarchy and the Creativity Network as Arm's Length

Connectivity, or, the degree to which the organizations or persons are linked to each other, is a major aspect of the network structure (Jansson, 2006). We can make a distinction between arm's length (external) and hierarchical (internal) networks. Arms-length relations are formed to facilitate concerted action on the part of autonomous organizations in situations where there is no formal authority to impose coordination, which corresponds to the structure of creativity networks. A network having an authority directly present within the network to control is defined as a hierarchical network, which corresponds to the process network in the theoretical framework.

The Project Network as an Extended Action Network

Aldrich and Whetten (1981), Jansson et al. (1995) and Jansson (2006) distinguish between action and organization networks. The action network is a temporary set of units, which has been established out of different units in the organization network for a specific purpose, e.g., to create a new product or service. The organization network is thus a larger and more permanent social structure, or the 'ordinary' hierarchical network of the firm, from which members are drawn for participation in temporary action networks. The project network in Figure 2 is an example of an action network, which is established to transform knowledge from the arm's length creativity network into a product/service. When the task of this network is completed, the action network is typically dissolved, and the units remaining in the organization network are awaiting formation of future action networks. Project networks are extended versions of action networks as they consist of both internal employees and external experts.

Three project networks explored in previous publications (Harryson, 1998; 2002) all demonstrated one and the same phenomenon: As they progressed from exploration to exploitation, they not only grew in size, but also went through a change in project leadership from a less senior person with informal management style to more senior and organizationally strongly positioned person. This is a reflection of the need to move from an open organic network to a more closed and hierarchic structure to manage the transition from exploration to exploitation. It is the management of this transition that can secure a conversion of knowledge creation into business implementation for implementation of innovation.

The transition was illustrated in the case when Spiderman established a project network to develop a revolutionary ceramic brake system. This started as a rather organic team of externally networked employees, who identified and integrated complementary skills and technologies from a broad variety of creativity networks, such as universities, and also from a few process networks, such as specialized suppliers in Europe and in the USA. As the project network shifted its focus from exploration to exploitation, a selection of the previously external experts were internalized into a Fastcar unit dedicated to commercializing the results. Through this integration, the project network partly transformed from an open arms-length network into a more closed and hierarchically controlled process network.

Drawing a Link to the Hypertext Organization

As an alternative attempt to clarify the distinction between action networks and hierarchical networks Nonaka's hypertext organization combines the stability of a hierarchical bureaucratic organization with the dynamism of the flat, cross-functional task-force organization through coordination of time, space and resources (Nonaka, 1994, p. 33):

> The hypertext organization is an organizational structure that enables orchestration of different rhythms or 'natural frequency' generated by various project teams and the hierarchical organization. It coordinates the allocation of time, space and resource within the organization so as to compose an 'organizational' rhythm that makes organizational knowledge creation more effective and efficient.

There are three layers in the hypertext organization. The lowest layer, the knowledge base, constitutes a corporate university of tacit and explicit knowledge, or a 'clearinghouse for the new knowledge generated' (Nonaka and Takeuchi, 1995, p. 170). The second layer, the business system, is the formal hierarchical organization in which the routine operations are carried out. This corresponds to the hierarchical networks in classic networking theories and the process networks in Figure 2. Finally, Nonaka's loosely linked self-organizing project teams, including the area in which they create knowledge, constitute the top layer corresponding to the project network in Figure 2.

Organizational knowledge creation is a process of dynamic knowledge and information cycles that traverse all three layers. Members of project teams are selected from diverse functions and departments across the business-system layer to engage in knowledge-creating activities. Once the task is completed, the team members move down to the knowledge-base layer to make an inventory of the knowledge created. When this is completed, the members move up again, back to their original business-system layer to perform routine activities until new projects are created. This is a continuous process and 'the ability to switch swiftly and flexibly between the three layers in the hypertext organization is critical to its success' (Nonaka, 1994, p. 33). Similarly, the success factor in Fastcar's commercialization of ceramic brakes was Spiderman's rapid access to experts *(die kurze Wege der Experten)* within and beyond the company. The knowledge created in the teams is different from that accumulated in the business-system, and both types of knowledge are mixed into the knowledge base of the hypertext organization. Fastcar acquired a unique ceramic technology for revolutionary break systems. Once acquired, the related knowledge and technology were stored and diffused to another division that applied them to also develop and commercialize a high performance clutch system.

Introducing Open and Closed Networks

Along the connectivity dimension of the social network, we can distinguish between open and closed networks. Having no social capital on which to rely, the open network is mainly about resource exchange of information, while the closed network focuses on social exchange, trust and shared norms (Walker et al., 1997). An example of an open network is one in which firms have direct social contacts with all their partners, but these partners do not have any direct contacts with each other. A high number of such non-connected parties, or structural holes, means that the network consists of few redundant contacts and is information rich, since people on either side of the hole have access to different flows of information (Burt, 1992; 1993). This implies that the structure of an open network is suitable when the purpose of the network is knowledge creation by maximizing the number of contacts gathering, processing and screening new sources of information. This kind of creativity network then stresses the indirect linkage, has mainly weak relationships and is loosely coupled.

The opposite is the tightly coupled closed network, where all partners have direct and strong ties with each other. This network is centered on social capital, which is built through trust and shared norms and behavior (Coleman, 1988). Embeddedness in dense networks supports effective knowledge transfer and interfirm cooperation (Ahuja, 2000; Granovetter, 1985; Walker et al., 1997). These characteristics compose an ideal process network in Figure 2.

Proposing an Optimal Network Structure

Ahuja (2000) highlights the contradiction between open and closed networks and proposes that the larger the number of structural holes spanned by a firm, the greater its innovation output. There seems to be a trade-off between a large loosely coupled network that maximizes information benefits and a smaller tightly coupled network promoting trust building and more reliable information. This contraction is studied in the context of project teams by Soda et al. (2004), who argue that the best performing teams are those with strong ties among the project members based on past joint-experience, but with a multitude of current weak ties to complementary, non-redundant resources. By mainly recruiting researchers who have already worked as academic collaboration researchers, Fastcar illustrates the suggested model of Soda et al. (2004) in getting project teams with high past closure (strong ties within the team based on prior collaboration) and high current structural holes (multiple weak ties to nonredundant resources at universities held by the new recruits). Fastcar's university collaboration is described in more detail by Harryson and Lorange (2005).

If we apply the findings of Soda et al. (2004) to our general framework in Figure 2, the project networks will typically optimize performance by having core team members who share strong past experience while also having many weak ties to complementary recourses that can take the form of creativity networks. Again, this corresponds to the project network of Spiderman, who had strong ties to all his internal team members – all of whom had many weak ties to complementary knowledge both within and outside of Fastcar. However, some of the nonreduntant external ties were strong – not weak. One example is the link to Mr. Grandissimo who provided the critical break pads. We may need further levels of distinction that goes beyond the initial argument of strong and weak ties – as initially proposed by Granovetter (1973).

Exploring the Strong Importance of Weak Ties

Granovetter is the pioneer in highlighting and exemplifying the importance of weak ties in linking otherwise unconnected networks. He argues that individuals with few weak ties have difficulties to be up-to-date with information from distant parts of the social system, and that 'social systems lacking in weak ties will be fragmented and incoherent' (Granovetter 1973, p. 106). In the context of innovation he argues that new ideas more often emanate through weak ties from the margins of a specific network rather than through strong ties from its core or its nucleus. Accordingly, the relative strength of weak ties can transform marginal idea creating networks into a new nucleus of innovation. This argument poses new challenges to the science of innovation management: if the idea creation process is centered within and around marginal networks and their relatively unstructured weak ties, it becomes difficult to manage the main source of innovation and hence also difficult to control the innovation process as a whole – at least if attempted to do it all within one and the same company.

As it is argued that weak ties can be developed and leveraged quite easily (Håkansson et al., 1999), the good news is that creativity and new ideas can be acquired with no trouble. On the other hand, the weak tie argument suggests that it is very challenging to influence the outcome of such creativity, as it is hard to actually control activities emerging through weak ties (cf., Tidd et al., 2001). In many cases, innovation requires management of both weak and strong ties cutting across both peripheral and core networks with a strong focus on developing and managing relationships for transfer and transformation of information into innovation. Therefore, it seems critical to analyze and better understand the nature of the ties in the three types of networks outlined in Figure 2.

Weak Ties for Simplicity – Strong Ties for Complexity?

The main-argument of Granovetter (1973) is that distant and infrequent relationships, which represent weak-ties, are efficient for knowledge acquisition and sharing as they offer access to new knowledge by bridging otherwise disconnected individuals and spheres of knowledge within or across organizations. Similarly, Weick (1976) argues that organizational entities that are only loosely tied to other entities are more adaptive because they are less constrained by the organization system of which they are part. Put simply, they can raid around and tap into others' brainpower without getting tied up by formal requirements to assist various teams or units.

Hansen (1999) uses a network study to explore how weak inter-unit ties help a new product development team with purposeful knowledge-sharing. His findings are that while weak ties help the team find new knowledge located in other units, the weak ties are not useful in supporting the actual transfer of complex knowledge. The more complex the knowledge, the stronger the ties required to support its transfer. If these findings are correct, it would be reasonable to assume that weak ties will accelerate development speed when the required knowledge is not complex. Conversely, weak ties will not be supportive, or even slow down speed, in situations of high knowledge complexity. Research findings by Hite and Herstley (2001), Uzzi (1996), Rowley et al. (2000) and Van Wijk et al. (2004) confirm that strong ties are positively related to firm performance when the environment demands a relatively high degree of exploitation, and that weak ties are beneficial for exploration purposes and to prevent the network's insulation from market imperatives.

A critical problem remaining unsolved by all authors reviewed in this last section is that of managing and steering the 'uncontrollable fuzzy front end' of innovation, as this depends mainly on weak ties. In this context, the arguments of structural holes and bridge ties, outlined below, offer new possibilities to take better control of innovation networks.

Using Structural Holes and Bridge Ties to Take Control of Networked Innovation

Burt (1992) describes the way in which social structure renders competition imperfect by creating entrepreneurial opportunities for certain players and not for others. He distinguishes between: financial, human and social capitals, and argues that social capital is as critical as financial and human capitals. Social capital is at once the structure of contacts in a network and resources they each hold, in particular who they can reach and how they can reach them (know who). Easily accumulated contacts with alike people do not expand the network as much as they fatten it, weakening its efficiency and effectiveness by increasing contact redundancy and tying up time. Burt (1992, p. 72) holds that 'increasing the network size without considering diversity can cripple the network in significant ways'. What matters is the number of nonredundant contacts, which lead to new people who bring new information benefits.

A network dense with redundant contacts is virtually worthless as a strategic networking device because the strong relations between people in the network means that each person knows what the other people know, so they will discover the same opportunities at the same time. The dense network is inefficient in the sense that it returns less diverse information for the same cost as the sparse network. A solution is to put more time and energy into adding nonredundant contacts to the dense network. Nonredundant contacts are connected by a structural hole, which is a relationship of nonredundancy between two contacts. The hole is a buffer, like an insulator in an electric circuit. As a result of the hole between them, the two contacts provide network benefits that are synergetic rather than overlapping. Nonredundant contacts are disconnected in one of the following two ways: either directly in the sense that there is no direct contact, or *cohesion,* between the two persons, or indirectly in the sense that one person has contacts that exclude the other person's contacts. Conversely, two contacts are redundant to the extent that they are connected to each other by a strong relationship, which indicates the absence of a structural hole.

The optimized network has two design principles: *efficiency* and *effectiveness.* The efficiency principle says that you should maximize the number of nonredundant contacts in the network to maximize the yield in the structural holes. The effectiveness principle requires a shift in perspective. Burt (1992) distinguishes between primary and secondary contacts and recommends a focus on resources to preserve the primary contacts. The shift in perspective is that contacts are not people on the other end of the contact's relations; they are instead ports of access to clusters of people. Instead of maintaining relations with all contacts, the task of maintaining the total network is delegated to primary contacts. Where efficiency concerns the average number of people reached with a primary contact, effectiveness concerns the total number of people reached with all primary contacts. Accordingly, efficiency concerns the yield per primary contact, while effectiveness concerns the yield of the network as a whole. We typically tend to live in clusters of strong relationships, which allow information to circulate at a high velocity, but each member of the cluster tends to know what the other members know as well. Therefore, and this is the key proposition of Burt (1992, p. 82), 'the spread of information on new ideas and opportunities must come through the weak ties that connect people in separate clusters'. Weak ties are essential to the flow of information that integrates otherwise disconnected social clusters into a broader society.

Burt's structural-hole argument complements the strength of weak ties argument of Granovetter (1973) in two interrelated ways. First, the causal agent in the phenomenon is not the weakness of tie itself, but the structural hole that it spans. Tie weakness is a correlate, but not a cause of access to nonredundant information. Second, by shifting attention away from the structural hole responsible for information benefits to the strength of the tie providing them, the weak-tie argument obscures the control benefits of structural holes. In other words, the structural-hole argument gives us new possibilities to manage and steer the previously uncontrollable information benefits in the fuzzy front end of innovation. While Granovetter's (1973) weak tie argument focuses on the strength of relationships that span the chasm between the two structural clusters, Burt's (1992) structural hole argument is about the actual chasm spanned – not on the strength of the relationship that spans the gap. It is the chasm spanned that generates information benefits through its function as a bridge over a structural hole. Nonredundant (typically weak) ties are bridges to other clusters. The bridge strength is an aside in Burt's (1992) structural hole argument, because information benefits are expected to travel over all bridges, strong or weak. His focus is more on how networking benefits vary between redundant and nonredundant ties, which are not always equal to strong and weak ties. The task of the strategic player is to build an efficient and effective network through excellent selection, development and nurturing of bridge ties. Full attention to relationship management is key to preserve the information benefits of bridges, or else they will 'simply' fall into their natural state of being weak ties.

The bridge tie of Spiderman to Mr. Grandissimo was very strong indeed and yet it closed a structural hole between Fastcar and an external network that secured partly exploration and mainly exploitation (production) of ceramic materials for break pads. Accordingly, we have reasons to believe that access to complementary nonredundant resources and skills also can be given through strong ties – and not only through weak ones.

Summarizing Complementarities of Strong and Weak Ties

Based on the arguments outlined above, it seems reasonable to assume that strong and weak ties are complementary from the perspective of time, and that the structure of an ideal network should maximize the yield per primary contact. We also learn that weak ties are likely to promote diversity and creativity in idea creation and accelerate development speed in early phases of exploration when the required knowledge is not complex. Conversely, weak ties may slow down speed in situations of high knowledge complexity where strong ties are required to support integration of results for exploitation of innovation. Accordingly, it seems that radical innovation requires management of both weak and strong ties cutting across both peripheral and core networks with a strong focus on developing and managing relationships for transfer and transformation of information into innovation across multiple levels. Weak ties seem to be particularly useful in open creativity networks to enrich the creation and exploration of new knowledge. Wide know-who will be the main-driver in extensive networks of complementary (non-redundant) knowledge. Conversely, strong ties are more critical in rather closed process networks to drive the integration of innovation – from a creative concept into solid business plans, prototypes and commercial products. Strong know-how is the driver in a focused network of similar knowledge. Know-who will add complementary knowledge when required. As illustrated by Spiderman, this complementary knowledge can also be acquired by a strong bridge tie across a structural hole – and not always through weak ties. One of the main hypotheses proposed and explored in this paper is that successful spidermen are highly multicompetent acting in core teams of past strong ties to process networks and a multitude of current weak ties to creativity networks. Their interconnecting position in the network structure presented in this paper is illustrated in Figure 3.

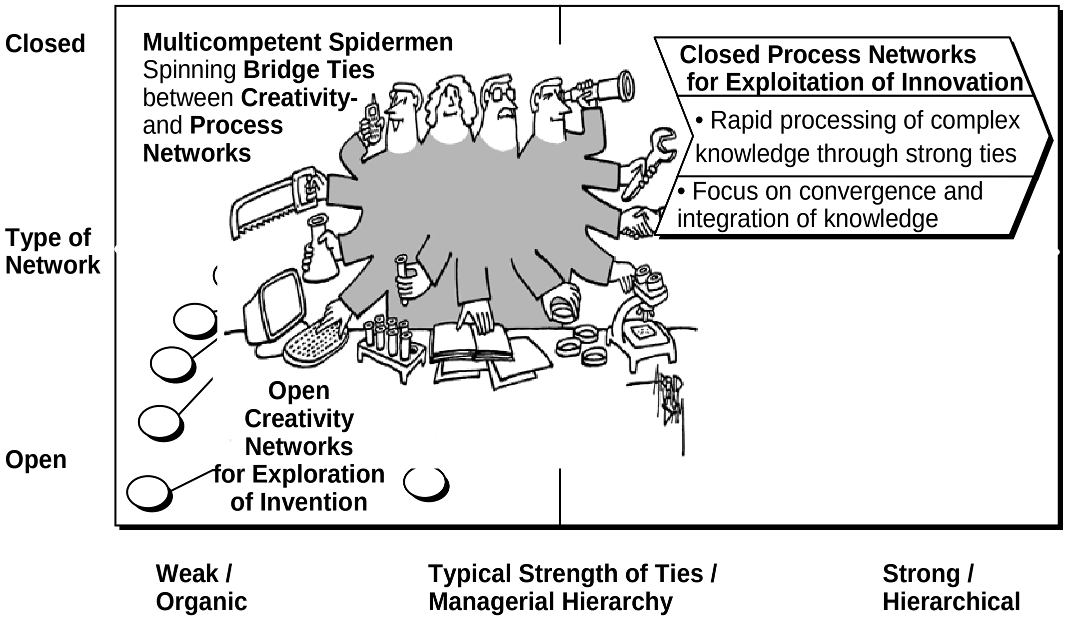

Figure 3 A Networked Perspective of Know-Who Based Entrepreneurship

Figure 3 summarizes the network perspective of know-who based innovation networks. The figure still puts project networks at the core, but with a clearer positioning of how these networks depend on multicompetent spidermen who can interlink the complementary and yet structurally contrasting networks: open vs. closed, and (typically) weak vs. strong ties in organically vs. hierarchically managed networks. Our framework suggests that firms with relationships in open networks have greater latitude in their innovation strategies as they have more extensive and nonredundant opportunities for collaboration (Burt, 1992). Also, the more social capital available to a firm in terms of know-who and relationship-ability, the less resources it needs to manage existing relationships and the more resources it can use to establish new ones (Walker et al., 1997).

As outlined in our paper, the stage of profiting from networked innovation is mainly a result of having openness in the sense that a company does not only have an open policy to the exploration phase, but is also partially open in the exploitation phase and allows for other companies to profit from its own innovation efforts – while getting licensing income in return. Further examples from our research enhance the generalizability of this finding: Anoto based its creation on networking with Ericsson engineers and by running some 30 master thesis projects and three PhD projects with Lund university. For exploitation of the results, Anoto licensed its technology to a large number of companies across several industries and established commercialization relationships with large companies like Logitech, Nokia, HP and Hitachi (Harryson and Kliknaite, 2005). Similarly, Bang and Olufsen developed a unique audio power conversion technology through university collaboration and their spin-off company ICEpower (Harryson and Lorange, 2006). This technology is both enhancing the performance of their own products, while also giving significant income through licensing agreements with companies like Audi for car stereos and Samsung for mobile phones (Harryson et al., 2006).

Conclusions

This paper integrated different networking theories and areas of research in new ways to expand our understanding of how know who based innovation networks can build new bridges between exploration and exploitation. It also introduced a fresh empirical case to illustrate and analyze the links between theory and practice in the dynamic sphere of increasingly networked and open innovation. As a main contribution of this paper, the bridges and links were integrated into a new management approach that uses know-who based networks to manage the transition from knowledge creation and exploration to business implementation and exploitation. Even though a certain quantity and quality of own research and review of others' contributions have been accomplished, it would be beneficial to make a deeper review and analysis of how different streams of research, across not yet related disciplines, can help us manage these bridges and links in more effective and efficient ways across individuals, teams, units and organizations. Further empirical research would support stronger links to practical realities in industrial contexts – perhaps beyond the one covered in this paper. If we pursue further qualitative research to better understand the complex interrelationships across levels and unist of analysis, we may also be able to pursue purposeful quantitative research to deepen our understanding of selected aspects. So far, my feeling is that we have only produced a few drops of the ocean of wisdom required to solve the conflict between collaboration and competition in open innovation – fighting against the era of intensified IP violation.

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