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Towards networked R&D management: the R&D approach of Sonera Corporation as an example

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In this paper the authors delineate the challenges of a dynamic environment to R&D management. The authors build on most recent ideas, such as the dynamic capability view of the firm, as strategic foundation for modern R&D management. Collaboration is emphasized as a meta-capability for innovation. These ideas are merged into a 'Networked R&D Management' approach that emphasizes internal and external collaboration networks as critical for companies operating in a dynamic business environment. The approach is illustrated with ICT industry as an example. The implementation of Networked R&D Management is reflected in the illustrative case discussion of R&D management of Sonera Corporation.[1]

1. Emerging ICT industry as an example of a dynamic environment

Due to convergence, deregulation and blurring boundaries, the telecom, content and information technology industries have been going through a major transformation and developing into an ICT industry. The simultaneous convergence of industries, technologies and equipment, as well as the related demand for interoperability create complexity (Day and Schoemaker, 2000), as do the simultaneous management of different technology generations (e.g. cellular technologies) and emerging new standards. Standards are critical for the evolution of markets and the competitive position of companies. Standards are especially crucial in the ICT markets with strong network effects, where customers value compatibility highly. Interoperability and compatibility, i.e. standards and rules, and rules that enable subsystems of products to work together without special modification, are crucial for the users, manufacturers and service providers (John *et al.*, 1999, p. 81; Teece, 1998). Technological uncertainties are caused by simultaneous developments of several technologies, the pace of which are almost impossible to forecast due to several interdependencies[2] and

multiple factors impacting the techno-economic development.

Technological change creates incentives for innovation and entrepreneurs seeking opportunities. Technological discontinuities bring along new innovative players who try to break the rules of competition and seek the niches not noticed by the incumbent players. The incumbents are often challenged by the needs of the existing customers, rigid organizational culture and structures described as 'innovator's dilemma' Christensen (1997). For the incumbents the discontinuities pose a threat that may be turned to an opportunity through cooperating with innovative players and learning from them. Various partnerships are established as knowledge and technology options to share risks.

Customers' demand for new services, i.e. diffusion patterns for new products and services are one of the greatest sources for market uncertainty. New product versions might make older generations obsolete. Market uncertainty has increased the risks and costs of R&D. A third factor creating uncertainty for the ICT sector are the regulatory policies. Market deregulation has accelerated global competition and boosted innovation and cost-efficient services.

With respect to telecom and software industries, Eisenhardt (2002: 88) notes that 'the play on that field is high-velocity with strikingly nonlinear instability, unpredictability and ambiguity'. Large and incumbent players have come to a situation where they must ceaselessly create, adapt and design new products and services in order to maintain their competitiveness. New technological competencies must be blended and absorbed in the company, as new technologies and business concepts demand new capabilities. Product and service innovations appear constantly across companies and industries, often through unplanned interactions. Most firms are networked vertically with many value-chain partners, and increasingly, they will be allied laterally across industries (Coombs and Metcalfe, 2000: 210; Miles *et al*., 2000: 310–318). As a result of this development the ability to leverage diverse knowledge from non-redundant networks has become a critical capability.

In this paper we review the state-of-the-art of the R&D management theory based on fourth and fifth generation innovation management (Miller and Morris, 1999; Rogers 1996). We base our approach on these ideas, and develop our framework further in the light of the dynamic capability view of the firm (Teece *et al*. 1997; Teece 2000). Collaboration is also emphasized as a meta-capability for innovation (Miles *et al*., 2000). The fusion of these ideas, the 'Networked R&D Management' approach emphasizes internal and external collaboration networks as critical for companies facing a dynamic business environment. We illustrate Networked R&D Management with ICT industry as an example and discuss the R&D management of Sonera Corporation as a case example. Our approach can be described as participation action research (Ottosson, 2003), where the researchers act not only as researchers but also actively participate in the business. The combination of the inside and outside views enables a deeper understanding of the complexity in R&D management. The participation action research approach reveals also soft issues and enables a holistic understanding (Ottosson 2003: 87). Two of the authors for this paper have worked for the case company's R&D management for several years. All authors have clinical experience from other companies, and also a solid academic background in the areas of knowledge management, strategy, and innovation management as well as information and communications technology.

2. R&D management in a dynamic environment – state-of-the-art theory

This section provides a state-of-the-art theoretical review on the critical building blocks of competitive R&D management in a dynamic environment. The review comprises the most recent essential ideas in R&D management, the dynamic capability view as a source of organizational renewal, and collaboration as a meta-capability for innovation.

2.1. Generations of R&D management

The evolution in the meaning, contents, and practice of R&D management has been described as generations of R&D and innovation management (e.g. Roussel *et al*., 1991; Rothwell, 1994; Rogers, 1996; Miller and Morris, 1999; Miller, 2001). In the first generation model (begun around 1900), R&D is seen as an overhead cost lacking a strategic framework, as of example future technologies are in the hands of the R&D function alone. The second generation model takes a more systematic approach more specifically attuned to business needs. This second-generation model is managed on project-by-project

basis, however hence missing an aggregate view. Managers find it difficult to establish priorities among projects within each business, across businesses, and for the corporation as a whole (Roussel *et al*., 1991). Even though several authors present this stage as belonging to the past, some features of it are still practiced in many companies.

The third generation model is both purposeful and strategic. It involves managers from different functions to share and pool their insights to decide what to do, why, and when. It includes technology portfolios, roadmaps, and lifecycle considerations. Miller (2001) states that third generation management seeks to create a strategically balanced portfolio of R&D, across business units, across divisions, and across the corporation formulated jointly in a spirit of partnership between general managers and R&D managers. The R&D strategy is then linked to the overall business strategy. It can be argued that many advanced companies today establish and run their R&D management according to the third generation model.

The fourth generation R&D has a broader mission for R&D as a leader of technologically enabled discontinuous innovation (Miller and Morris, 1999: 17). Integration and parallel development are essential features of the fourth generation innovation model (Rothwell, 1994). This means that suppliers are integrated into the new product development process at the early stages. Activities from in-house departments are integrated, as well enabling them to work simultaneously in a project.

Howells *et al*. (2003) state that the shift from serial to simultaneous and parallel working in innovation has become more commonplace. Managing the technological knowledge boundaries of the firm in the scope of competitiveness now depends strongly on the effectiveness with which the firm can gain access and utilize sources of technological knowledge and capabilities beyond its boundaries. According to the knowledge-based view of the firm, the knowledge-based assets are the critical resources and key to competitiveness (Nonaka, 1994; Grant 1996b; Teece *et al*., 1997; Nonaka and Takeuchi, 1995; Spender and Grant, 1996). The intellectual roots of the knowledge-based view lie in organizational learning (Argyris and Schön, 1978; Senge, 1990; Leonard, 1998). In the knowledge-based view of the firm, the firm is seen as a repository of knowledge (Fransman, 1998), an institution for integrating knowledge (Grant, 1996a) and a body of knowledge (Spender, 1996).

Miller (2001) has delineated a set of principles and practices that define the scope of the fourth generation innovation and R&D management (related references presented in parentheses):

- management of knowledge from diverse sources (Davenport and Prusak, 1998; Pfeffer and Sutton, 2000);
- expeditionary marketing through mutually dependent learning;
- integration of explicit and tacit knowledge (Nonaka and Takeuchi, 1995);
- models for competitive architecture and organizational capability;
- new organizational models (Miles *et al*., 1997; Goold and Campbell, 2003);
- new approaches to finance, decision making and accounting;
- the management of technology represented in the form of intellectual property (for more, see e.g. Teece, 2000; Chesbrough, 2003b);
- a new innovation process (refers to a spiral innovation process; flexible development process discussed in e.g. MacCormack *et al*., 2001);
- a process and tools through which these elements are integrated (Rosenau *et al*., 1996; Cooper *et al*., 1998; Belliveau *et al*., 2002).

In this fourth generation R&D 'industry structure is presumed to be more dynamic, and the scope of innovation management is broadened to include not just products and processes but business and market models that encompass the management of knowledge, technology, and market/industry infrastructure' (Miller, 2001).

The fourth generation R&D integrates customers and other partners in the entire conception and development process. Referring to the possibility of radical innovations, Miller and Morris (1999) note: 'New combinations or aggregations of knowledge, tools, technology, and processes change the underlying character of customer need by changing the boundaries of what is possible'.

In the fifth generation model innovation has been seen to become a network process comprising greater overall organizational and systems integration and broader horizontal networking (Rothwell, 1994). The fifth generation model emphasizes cross-border information management, and represents a more comprehensive process of the electronification of innovation across the whole innovation system (Rothwell, 1994). The management practices in the fifth generation R&D are knowledge-based and collaborative (Rogers, 1996). Rogers (1996) uses the term collaborative innovation system, which '...

focuses upon the total innovation system designed with suppliers, partners, distributors, and other stakeholders, including customers – all as integral participants in defining new frontiers.' Chesbrough (2003a) uses the term 'open innovation' to describe a new emerging paradigm that is strongly based on effective use of internal and external sources of ideas, knowledge, business models, and expertise. A business model can be defined as broadly as 'the business model is a business concept put into action'. (Hamel, 2000: 66, and an overview and discussion on its suitability to dynamic business environments in Soininen *et al*., 2003).

The continuous development in R&D management practices in the more advanced companies reshape and extends the list of unresolved management problems in other companies as well. Many of the principles embedded in the more advanced R&D management models, particularly the fourth and fifth generation models, have still not diffused into practice in a broader context. Scott (2000) provides a comprehensive analysis of the unresolved technology management problems in the new product development processes of high-tech product companies. This Delphi study uncovers the challenges for R&D management among academics and practitioners.

The fourth and fifth generation R&D models serve as the theoretical foundation of this paper. However, it needs to be augmented by internal capabilities provided by the Dynamic Capability View of the Firm as well as by collaborative R&D approaches. The resulting 'Networked R&D Management Approach' offers both a necessary theoretical framework for a holistic and strategic approach to R&D management, and some practical guidelines for implementation.

2.2. *Dynamic capability view of the firm as a strategic approach to competitiveness*

The dynamic capability view of the firm is increasingly seen as a relevant strategic approach in a dynamic environment (Teece *et al*., 1997). The dynamic[3] capability[4] view of the firm originates in the influential core competence thinking (Prahalad and Hamel, 1990) where the firm's potential for competitive advantage and competitive strategy may be traced to specific core competencies distinguishing one firm from another.

The dynamic capability view of the firm stresses the firm's *internal conditions*: resources, routines, competencies, capabilities, and accumulated knowledge as the most crucial factors in explaining the creation, maintenance and renewal of its market position and competitive advantage (Metcalfe and James, 2000).

When corporate R&D is seen as a source for a firm's renewal and competitiveness, the dynamic capability view of the firm gives a strategic perspective to managing R&D activities. According to the dynamic capability view of the firm, path dependent and firm-specific core competencies and R&D management as engines for the renewal of technological core competencies become the key source for organizational competitive advantage. The dynamic capability view of the firm emphasizes the dynamics in the competition arena and competing firms. It can be seen as an emerging paradigm to understand how competitive advantage is achieved in dynamic industries like ICT (Teece *et al*., 1997; Powell, 1998; Eisenhardt and Martin, 2000; Blomqvist *et al*., 2002).

2.3. *Collaboration as a meta-capability for innovation*

In a dynamic environment, the role of collaboration, that is the ability to interact with other parties on individual, team, departmental, and organizational levels, is highlighted. Unsuccessful alliances and coalitions often fail for a very simple reason – they are not created or utilized collaboratively (Miles *et al*., 2000). The dynamic capability view does not explicitly discuss internal or external collaboration as a critical capability, but collaboration is an integral part of learning, transformation and integration of resources and knowledge.

Von Krogh *et al*. (2000: 4) describe the firm as 'a dynamic entity, which actively interacts with others and the environment. . .and has the capability to continuously create new knowledge out of existing firm-specific capabilities'. Birkenshaw (2001: 12) notes that 'at the heart of the knowledge management movement is the simple concept of the firm as a social institution'. Also Kogut and Zander (1992) see firms more as social communities for voluntaristic action than as 'nexus of contracts' in organizational economics. In a similar vein, Grant (1996b: 112) confirms that the power of firms (instead of markets) is in their ability to 'efficiently develop and utilize tacit knowledge and create conditions under which multiple individuals can integrate their specialist knowledge'.

The ability to develop internal and external collaborative relationships is essential for R&D management. Hence, knowing how to collaborate helps the firm to create and transfer knowledge. Knowledge creation and utilization, in turn, lead to innovation (Miles *et al*., 2000: 300). Miles *et al*. (2000) bring collaboration explicitly forth as a meta-capability and the voluntary aspect of innovation: 'innovation cannot be managed hierarchically because it depends on knowledge being offered voluntarily rather than on command.' They also emphasize time, trust and shared mental space as pre-requisites for collaboration (see Figure 3). According to Blomqvist (2002), trust is seen as increasingly critical in the technology-based collaboration between diverse actors. It is a critical factor in both internal and external collaboration, and thus the ability to create trust and collaborate are both among the key success factors when competing in a dynamic environment.

Beneficial collaborative relationships help an organization to renew the use of resources effectively and to gain essential information and knowledge in a changing environment. The emphasis on collaboration as a meta-capability underlines the capability to collaborate, as well as the quality of the collaborative relationships with internal and external stakeholders.

3. Towards Networked R&D Management

In a dynamic environment, R&D management increasingly consists of network activity that demands related capabilities. This section delineates the determinants of Networked R&D Management and related environmental drivers.

3.1. Dimensions of Networked R&D Management

The key dimensions of Networked R&D Management will be discussed in this section. The section concludes with an illustrative summary table, where the environmental drivers and suggested Networked R&D approach are depicted, see Table 1.

In Networked R&D Management value creation and innovation becomes a shared activity like. One of the basic assumptions behind the idea for Networked R&D Management is that value cannot be created in isolation, but in close collaboration with other actors. The R&D management must be able to manage very different external actors simultaneously, e.g. large global partners, small innovative suppliers, venture capitalists, standardization authorities, governmental authorities, and customers. In addition, the R&D management must be able to understand and coordinate internal activities with the human resource development function, the financing department, sales and marketing, internal development etc. Modern R&D management is increasingly becoming management of networks of asymmetric actors.

Miller and Morris (1999: 22) note: 'no single department – including R&D itself – has the full knowledge needed to carry out the responsibility for innovation, which is now obviously an activity involving the entire organization and extending to include suppliers, customers, and other external partners as well'. The key internal and external stakeholders are shown in Figure 2.

Scope of R&D

In the scope of R&D, non-technological issues are increasingly emphasized. Much of the technology is becoming an enabling factor. Because of harsh global competition and networked economy, state-of-the art technological knowledge disseminates fast. Thus the competitive edge based solely on technological core competencies may diminish and companies need to understand the sources of competitive advantage more broadly. Consequently, the scope of R&D is changing to include such issues as new business models, intellectual property rights, organizational adoption of knowledge and innovations, and consumer behavior (see also Chesbrough, 2003b).

Many ICT products are bundled together as systems of products and services, e.g. a personal computer, the operating system and applications. The compatibility and interoperability of complex systems, services and products are crucial for emerging new industries. In addition, the know-how bases are diffused across firms, industries, and customers/users. The complexity and systemic nature of the services set a natural demand for networked collaboration with complementary partners, complementary suppliers, and complementary customers (see Figure 1).

Locus of R&D

In order to be able to leverage the national – and global – innovation systems, companies need

Table 1. An illustrative summary of the environmental drivers and networked R&D management approach.

Dimension Management approach	Environmental drivers	Networked R&D
Scope of R&D	Much of the complexity and uncertainty arises from non-technological issues. Uncertainty due to technological and market uncertainty demand a holistic approach to R&D management.	Focus on new business models, customer needs, market trends and IPR issues. Technological success is dependent on non-technological factors, such as collaboration capability in complementary networks.
Locus of R&D	Increasing technological complexity and need for interoperability demand multi-disciplinary technological knowledge. Lean organizations and search for cost-efficiency enable only a limited number of in-house R&D experts and projects.	Major R&D investments outside corporate boundaries. Options strategy. Technology increasingly insourced through universities and research institutes. Absorptive capacity to insource R&D and the capability to evaluate R&D partners' capabilities become critical competencies.
Organizing for Networked R&D	Instability and organizational rigidity due to continuous changes in formal organizational structures.	Managing collaboratively independent actors in networks of interdependent competencies and knowledge. Cross-functional collaboration and informal networks complement formal structures. Flexible organizing modes: virtual teams, communities of practice, cross-border boundary spanners. Being able to access the right networks or communities through established weak linkages to be leveraged later when needed.
Integrated R&D strategy	Market and technological uncertainty demand both flexibility and agility from the R&D strategy and its implementation.	Focus on firm-specific and path-dependent dynamic capabilities. Strong collaboration with external complementary partners and continuous coordination with corporate strategy process.
Role and nature of innovation	Global competition, technological change and connectedness have decreased the traditional sources of competitive advantage. Focus on short-term issues, "quartile economy". Firms face the challenge of how to combine short-term business needs with long-term research enabling strategic renewal.	Continuous innovation as a key source for competitiveness, customer value and profit. Both incremental and radical innovations. Simultaneous and coordinated cross-functional and cross-border collaboration in research, development and sales. Actors' different roles in the dynamic environment must be managed, coordinated and linked.
Knowledge, competencies and IPR	Knowledge is dispersed and competencies are only state-of-the art. Challenging management of dispersed knowledge of asymmetric actors. Digitized products and changing legal system, e.g. US-based business method patents.	Company's knowledge base attuned to internal and external requirements (e.g. flow of ideas and knowledge). Focus on knowledge creation and appropriation. IPR as a critical part of intellectual capital. Intellectual property rights increasingly important for signaling and defending the competitive position. Cross-licensing, IPR portfolio as a focal technology asset.
Customers, partners and suppliers	Customers are expecting continuous and measurable value creation through innovation, yet strong focus on efficiency and cost reduction. Because of the distributed knowledge, complexity, high risks and need for interoperability, innovation has become a shared activity.	Customer orientation and close collaboration at strategic and operational levels. Customer needs and requirements churned from the value chain (1st tier customers, 2nd tier customers, etc.). Outsourcing/insourcing activities that are not core competencies/ create value add. Both long-term and short term relationships at strategic and operative levels.
Financing	Increased costs due to multi-disciplinarity and complexity. High risks due to technological and market uncertainty.	Collaborative R&D, risk-sharing even with competitors in pre-competitive R&D. Leverage of venture capital financing, funding from the EU and national research financiers.
Role of information technology	In the dynamic environment the flexibility of IT systems is accentuated.	Flexible IT systems that support internal and external knowledge sharing, and inter-system integration.

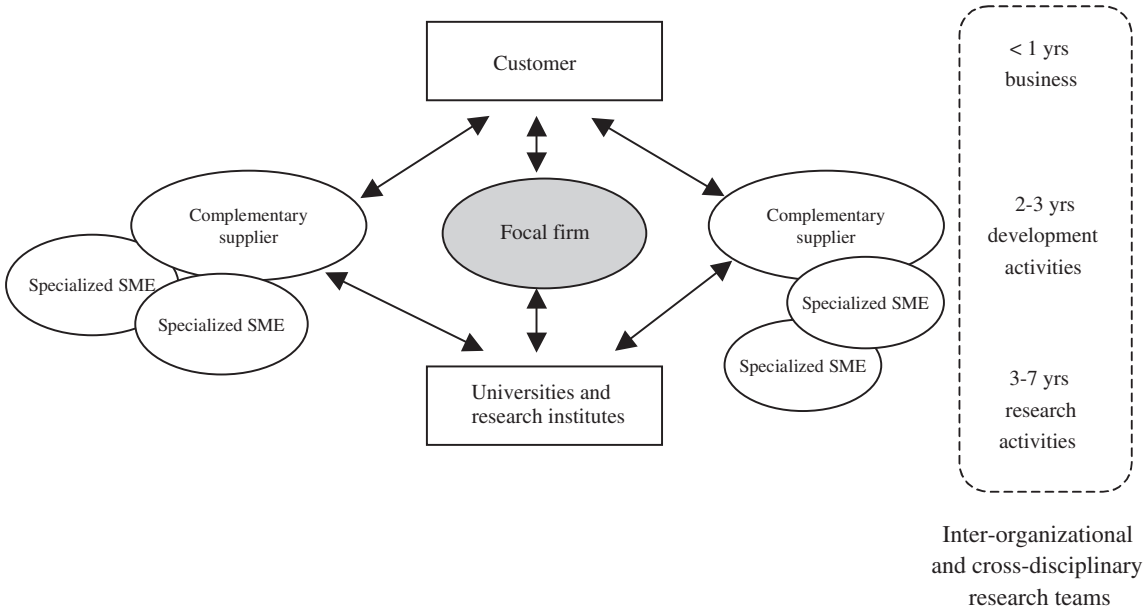

Figure 1. Networked R&D management through inter-organizational knowledge creation and learning.

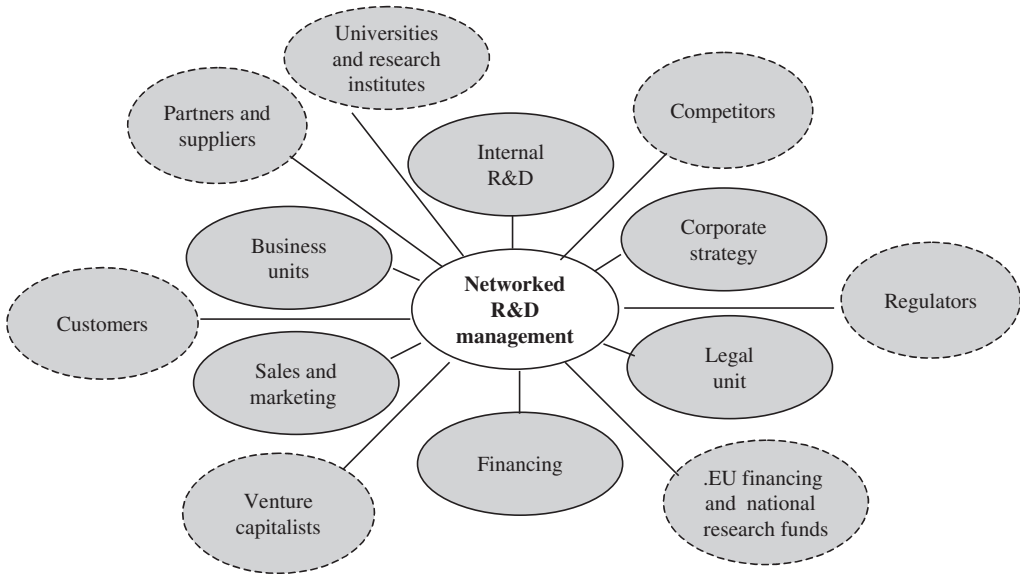

Figure 2. Internal and external stakeholders for networked R&D management.

unique core competencies, sufficient absorptive capacity (see e.g. Cohen and Prusak, 2001; Cohen and Levinthal, 1990), and collaboration capabilities. The locus of Networked R&D is clearly networked. In a dynamic environment, especially radical innovations are believed to emerge in border areas and networks. As a consequence, it is critical to understand and develop flexible integration of multiple knowledge bases and relevant mechanisms through which knowledge is integrated (Grant, 1996a). In high-risk areas, R&D collaboration can be used as an optional strategy, where small stakes in risky projects enable further investments. Both knowledge acquisition and risk sharing are major motivators for inter-organizational and university – industry R&D collaboration. Again, the collaboration becomes a meta-capability enabling the leverage of external knowledge and resources.

Organizing for Networked R&D

For long, R&D management has been too separated from business. In a dynamic environment,

R&D must be managed in a way that integrates different time horizons. As long as key account managers are measured mainly by short-term sales, this will not be possible. It would be worthwhile to find synergies between short-term sales activities and long-term research. Key customers are looking for value creation in the form of increased insight and understanding of future business. Key account managers could provide their customers with added value through business model scenarios provided by corporate research networks. R&D activities can thus be organized in a way that also present business needs are taken into account through managerial seminars and other activities.

Shared responsibilities, for example, 50% in research and 50% in development, stretch the actors' roles and enhance knowledge transfer and commitment. In a similar vein, a key account manager can work part-time in business concept innovation development projects. Leveraging asynchronous roles and shared learning of asymmetric actors may enable double-loop learning (Argyris and Schön, 1978). This type of networked R&D Management may also enable the development of radical business models.

Integrated R&D Strategy

Business and R&D strategies are too often planned in separated 'worlds'. Goodman and Lawless (1994) refer to this as 'the technologist view of strategy conflicting with the strategist view of technology'. On the other hand, R&D and technology strategists are usually criticized for developing technologies for technologies' sake and forgetting true business and customer perspectives in strategy formulation. Second, even though the R&D strategy is planned from a formal customer and business perspective and integrated with the general business strategy at the strategy formulation stage, the corporate level perspective and integration are often lost in the implementation phase.

Increasingly, it is the implementation phase that is challenging. In the Networked R&D model it is not only a question of the corporate internal strategy and vision, but of a shared vision, coordination and even complementary strategies at the network level of key stakeholders[5] (e.g. Thomke and von Hippel, 2002).

The goal of a broad customer-based R&D strategy is to develop superior technologies and products to offer customers better value than the competition does, which is the fundamental purpose of business. An integrated, customer-based R&D strategy must take a broad view: instead of a narrow new product orientation, the view must include broad technology and innovation issues. Strategic customer-based R&D may have to tackle with such issues as technological and organizational architectures (including operational innovations), and finally the corporation itself (business model innovations), in addition to traditional new product development. Eisenhardt (2002) points out that complicated markets demand simple strategies, where timing and the role of organizational coordination are critical.

Role and nature of innovations

Managing both radical and incremental innovations is a focal challenge in a dynamic environment. Discontinuous innovation demands fundamental questions, divergent thinking and discovery of new knowledge outside existing mental and organizational boundaries. Discontinuous innovation is driven by the future needs of customers, which the customers may not be able to articulate. Therefore, the customers must be incorporated as active parties in the innovation process, which becomes an activity of mutual knowledge transfer and co-learning.

Knowledge, competencies and IPR

Continuous innovation and competitiveness demand new knowledge creation and state-of-the-art competencies. Some authors claim that knowledge creation is even more important than knowledge appropriation, but especially in technology-oriented business the role of intellectual property rights has increased. They can be used for signaling competitiveness to customers, investors or potential partners, and for defending the competitive position through technology assets.

Customers, partners and suppliers

Value creation in close collaboration with customers can be decisive in dynamic industries where the emerging new technologies bring business opportunities for all. The challenge for the supplier lies in understanding the mainly latent customer needs. For the customer the challenge is to be acquainted with and to understand the possibilities provided by the new technologies. In

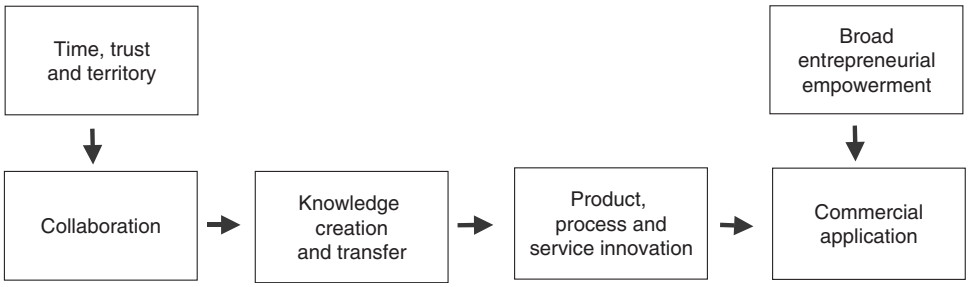

Figure 3. Innovation process (Miles *et al*., 2000).

addition to supplier-customer interaction, also interaction with complementary suppliers is needed. Learning by doing and learning in close interaction with the complementary network are useful methods to develop the whole market. In such a process co-learning, in which technologically enabled capabilities and concepts can be assessed and refined in the context of real need, can be practiced (see Figure 2).

Financing

Networked R&D model enables cost – and risk – sharing with complementary firms. Different forms of financing are used in high-risk research projects to make risk-taking and research of new areas possible. In pre-competitive research projects leverage of venture capital financing, funding from EU and national research financiers even in collaboration with competitors is possible.

Information technology as an enabling factor

In the dynamic environment the IT infrastructure should be able to accommodate internal and external changes quickly and at low cost. In practice the IT infrastructure is often rigid, and changes are expensive and slow to implement. A shared agenda with IT managers is needed. Prahalad and Krishnan (2002: 25) state that IT infrastructure '. . .must energize the internal organization, engage customers in dialogue and foster collaboration among all parties'. Especially in the converging ICT sector IT itself is a core technology enabling innovative new services and business models.

In comparison to so-called 3rd generation R&D management, companies will need to be integrated both within the company and across the network players. Subsequently they need to be closely involved with their key customers, suppliers and complementary partners. However, for most incumbent players the major challenge will be to adapt internal operations towards an integrated and customer-oriented way of working (on integrated enterprise, see e.g. Ghoshal and Gratton, 2002). Customer-oriented innovation demands a completely new internal way of operating, as well as strong internal collaboration to create total service concepts horizontally, and to serve the customers' needs. In Figure 3 a model on innovation process is presented by Miles *et al*. (2000). The model emphasizes time, trust and territory as critical antecedents for collaboration (territory as a mutual mental and physical space, see also the concept of BA; Nonaka and Konno, 1998).

Organizations must develop their capability to collaborate and enhance the quality of the collaborative relationships. Both internal and external collaboration is critical for the success of Networked R&D Management, where collaboration capability becomes a meta-capability enabling innovation.

4. The approach of Sonera Corporation to R&D management

This case illustrates some of the focal issues in Networked R&D Management. Especially in the ICT convergence, it is critical to understand how to leverage diversity, i.e. to get actors with complementary knowledge and resources to cooperate. Most of the major players are in a continuous cost-cutting mode in their search for efficiency and increased shareholder value. In the current economic situation, many European telecommunication companies and ICT companies seem to be very pragmatic in their research. However, for most players the search for the optimal strategic position in the emerging ICT market requires also strong corporate renewal through major competence development. Balan-

cing short-term business needs and long-term competitiveness through R&D is especially challenging.

Technological core competencies are critical also for Sonera competitiveness. However, as the Sonera's business model is changing, much of the needed technological core competencies will be different from today's competencies. In the past the scope of Sonera's R&D portfolio was quite dispersed. R&D projects were managed on project-by-project basis, which led to continuous discussions on the priorities. This approach comes close to the second-generation approach. The search for efficiency and effectiveness has led to a more focused approach. Today, the approach could be characterized as a mixed third- and fourth generation with many Networked R&D Management features being introduced.

The approach of Sonera Corporation includes a focused R&D portfolio and close linkage to corporate strategy and business units. The role of research involving both technological and business aspects to be able to grasp the change is emphasized. In Sonera's R&D management innovation is seen as a holistic process comprising also new business models and close focus on customer needs. For example, since 1999, the scope of the R&D management has clearly encompassed also research on new business models and intellectual property rights. This all hinges on core competencies and the capability to cooperate.

Technological competencies are built partly in-house, but increasingly in networks, e.g. in co-operative R&D projects with universities and complementary companies. Information technology has been a critical component for Sonera, as it aims for the emerging ICT markets. There has been a long-standing trend for acquiring software competencies and skills needed in the operator business. The IT systems' scalability and flexibility are critical for it to enable diverse value-add services to both consumer and business markets.

Business and societal issues as a scope of R&D

Even though technological knowledge is critical, according to CTO at Sonera Corporation, 80% of the complexity and uncertainty is related to business issues. Therefore, the R&D research portfolio should balance the research related to technology, business and human issues. Understanding the new business models, revenue models and intellectual property rights is crucial in Networked R&D Management and shared innovation. Predicting customer needs is challenging and can be best done in close collaboration with key customers. Many operators have customer access as a critical advantage but do not leverage it to its full potential in their R&D activities.

Focus on discontinuities and potential radical innovations

It has been critical for Sonera's R&D strategy and the related R&D portfolio to address the threats and opportunities provided by the high pace of technological change. In addition to incremental innovation, also radical innovations are studied in a specific unit. This unit delivers strategic projects in a virtual collaboration with internal and external experts.

The harsh competition and the emerging new technologies may together destroy much of the present business, which is based on traffic in cellular networks. E.g. the new terminals enable bypassing the operators' networks and using LAN and Bluetooth instead. Also VoIP (voice over IP) will be a major threat to the operators' present business models and earnings logic.

Customer-oriented innovation through collaborative R&D projects

Especially in the changing ICT markets the R&D management can bring increasing value to both internal and external customers (Gibbert *et al.* 2001). The change is difficult to grasp in the midst of the daily business. Front-line R&D experts can bring value-add through future scenarios or joint workshops on their specific research areas. Highest value-add can be delivered through close collaboration, e.g. key accounts, complementary suppliers, R&D experts and sales people can participate in joint workshops to anticipate and create future markets through shared learning. Sonera has also been an active participant in the successful Finnish innovation system, where the National Technology Agency sponsors the joint innovation of large corporations, SMEs and universities. Sonera has established close collaborative relationships with all major Finnish universities. The collaboration has been organized through boundary-spanners, which manage the relationships and portfolio of the research projects. There are also some new methods that are developed jointly with university partners to involve customers already at the business concept innovation phase.

Coordination with business units and corporate strategy

In Sonera, as well as in other major companies, there has been a continuous need to act in a coherent and integrated way. In order to develop customer orientation and increase the speed and transparency in the decision-making on new product development and other development projects, several decision-making boards have been established. Sonera's R&D management approach has been to connect business needs and R&D management through specific technology boards, where the business unit's top management participates in the decision-making. The decisions also mean priority support to these projects. Strong linkages between R&D and business units are critical for real-time knowledge transfer and mutual commitment.

5. Conclusions and managerial implications

As a response to the environmental changes, we can pinpoint some key activities in the Networked R&D Management approach. A holistic and multi-disciplinary approach is needed. The scope of the Networked R&D Management is broader than in traditional R&D management, and also non-technological issues, like new business models are emphasized (see also Chesbrough, 2003a, b). In order to increase flexibility and fast responsiveness, close integration with business strategy, as well as strong customer and market orientation have become crucial.

Networked R&D Management emphasizes both internal and external collaboration. Internal coordination and collaboration are still major challenges, and cross-functional in-company collaboration must be enhanced e.g. by setting up cross-functional teams. External R&D networks include collaboration and integration with complementary corporations, suppliers and customers, as well as universities and research centers. The non-core competencies are outsourced and leveraged from markets or collaborative partners. In the changing environment companies should focus on their dynamic capabilities beyond specific technologies.

Incremental and radical innovations have to be managed simultaneously, as do also the different time horizons and roles in the Networked R&D Management model. Co-learning within clusters of key customers, collaborating companies, suppliers and universities may enable both incremental and radical innovations. Especially in the emerging and dynamic markets the shared knowledge creation and innovation may speed up market development. Absorptive capacity and capability to manage independent actors in multiple networks become increasingly critical. Collaboration becomes a critical meta-capability enabling the development of all other capabilities. Fundamentally, the capability to collaborate in internal and external networks becomes a source for competitive advantage.

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Notes

1. Sonera Corporation and Telia have recently merged to TeliaSonera. The authors discuss the Networked R&D Management approach on the basis of their earlier experiences at Sonera Corporation and their research and practice related to R&D management.
2. According to Teece *et al*. (1997), the system level or architectural innovations often need new routines for task engineering and coordination and systems may display high interdependencies.
3. According to Teece *et al*. (1997) dynamic refers to a situation where there is rapid change in technology and market forces, and 'feedback' effects on firms.
4. According to Teece (1998) a dynamic capability is 'the ability to sense and then to seize new opportunities, and to reconfigure and protect knowledge assets, competencies and complementary assets and technologies to achieve sustainable competitive advantage'.
5. By networks we mean coalitions of complementary companies, small and innovative suppliers and key customers.