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# Towards Collaborative Worker-Centric Innovation Networks: A Conceptual Outline and Research Challenges

Falk Graser, Bremen Institute of Industrial Technology and Applied Work Science (BIBA) at the University of Bremen, Germany, T: +49 421 218-5539, F: +49 421 218-5610, grs@biba.uni-bremen.de

Jens Eschenbaecher, Bremen Institute of Industrial Technology and Applied Work Science (BIBA) at the University of Bremen,Germany, T: +49 421 218-5539, F: +49 421 218-5610, esc@biba.uni-bremen.de

Klaus-Dieter Thoben, Institute of Industrial Technology and Applied Work Science (BIBA) at the University of Bremen, Germany, T: +49 421 218-5529, F: +49 421 218-5610, tho@bibi.uni-bremen.de

## ABSTRACT

Today, ways of managing innovations is changing rapidly. In transition from traditional value-creation within one organization via value-creation in static Supply-Chains towards modern organizational forms like Dynamic Virtual Organizations and ICT-based Communities the concepts in managing innovation activities need to be adapted. As order-processing in general, innovation management became an inter-organizational issue, originating from diminishing vertical-ranges of manufacture, increasing specialization of research institutions, and the increasing involvement of customers into the innovation activities. Consequently, creating and bringing product innovations to the markets is becoming a networked process of companies and/ or individual workers. Recently, company based innovation has been investigated by several concepts, but human-centric innovation is widely unexplored and a coherent framework describing these kinds of innovation is missing. This paper follows the objective of giving an approach to a model for collaborative worker-centric Innovation Networks, and to state research challenges in detailing this model.

## INTRODUCTION

Production systems are acting within a dynamic environment forcing them to flexibly adapt to significant changes. Nowadays, globalization and increasing competition challenge enterprises to quickly develop customized products and services and to fulfil their customers' expectations for innovative solutions. Miles, Snow, and Miles state the assumption that enterprises survival in the future will predominantly be determined by their ability to quickly conceptualize, develop, validate, and market customized and innovative solutions [Miles; Snow; Miles 2000].

According to Paul M. Romer, innovation as seen from the macroeconomic perspective, is a process of providing multiplier-effects on investments in research and development (R&D) activities [Romer 1990]: Investments in R&D lead to an increase in knowledge, which can be turned into direct value by incorporating the new knowledge into new – innovative – products and services. Successfully bringing these new products and services to the market should provide earnings that exceed the original investments into the innovation process. Re-allocating these earnings by means of creating new jobs or increasing wages creates multiplier-effects. Aggregated across an economy, returns on investments in R&D leverage the strength and competitiveness of all the innovating entities within the economy, and, subsequently, of the economy as a whole. This thinking points-up the enormous significance of innovation for the single innovating entity and for the economy this entity is embedded in.

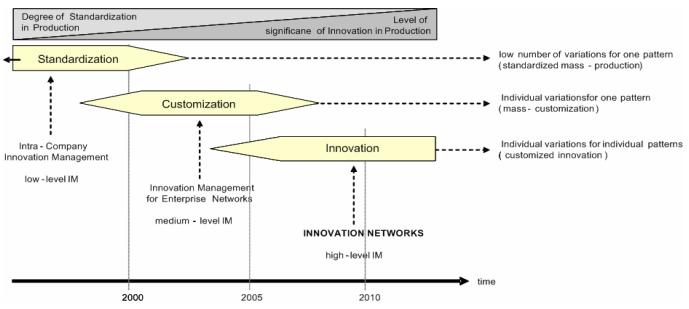
Innovation, by its traditional meaning, is an intra-company process in which entities from only one organization are engaged [Rothwell 1994]. These entities are sharing a common understanding on culture, processes, and standards in Information and Communication Technologies (ICT). Recently, this traditional paradigm is challenged in the maelstrom of globalization: confronting discrete stages in the innovation processes with the make-or-buy question increasingly leads to the decision of outsourcing parts of the innovation processes due to reasons of cost-efficiency. Relocating these parts arises from both outsourcing industrial R&D activities to entities abroad [Engardio; Einhorn 2005] and from a worldwide migration of academic researchers to the most attractive locations [Chu 2004].

All this is blowing the entire innovation process into bits of work and scatters these bits across the globe. Nevertheless, disintegrating processes from their traditional intra-company environment requires counteraction by reintegrating them into a larger inter-company environment: the bits of work somehow need to be streamlined to lead to consistent and efficient solutions. Specifically for the case of innovation such kind of inter-organizational environment is called "Innovation Network" [Haritz 2000]. In the end, academia and industry are confronted with a variety of challenges in describing and managing organizational structures, collaborative patterns, such as supportive ICT infrastructures and applications for this emerging organizational model.

Figure 1 summarizes the considerations stated so far, emphasizing the path from standardization via customization to innovation and the related changes in organization models and foci in innovation management.

A look at the state-of-the-art in research in Innovation Networks reveals that present concepts in that field are based on networks of enterprises [Haritz 2000]; [Forfas 2003]. On the other hand, emerging manufacturing concepts clearly show the need to focus on the role of

*Figure 1: From Standardization to Innovation*



the individual worker in value-creation processes [Collaboration@Work 2005]. Consequently, we believe that existing concepts in Innovation Networks must follow that trend.

By this paper, we take-up this belief and inquire the challenges that need to be addressed in developing a coherent framework for worker-centric Innovation Networks. For that, the paper is organized as follows: First, the conceptual "ingredients" to these networks are to be identified and integrated to a conceptual outline of Innovation Networks. Second, a state-of-the-art concept on Innovation Management for enterprise networks is presented and assessed to the requirements of collaborative worker-centric Innovation Networks. Third, a set of research challenges is stated based on steps one and two. A brief discussion will conclude this paper.

## BASIC CONCEPTS AND PROBLEM IDENTIFICATION

### Business Networking

Assuming that the term "business" summarizes all goal-oriented commercial, professional, and industrial activities performed by or between individuals, organizations, or enterprises we can state that the term "innovation management" summarizes all business-related activities with the goal to design, develop, and market new products, services, or conglomerates of both – so-called Extended Products [Wikipedia 2005]; [Thoben; Eschenbaecher 2003]. Emerging in the early 1990's, concentration on core competencies and subsequently outsourcing and globalization lead to low vertical range of manufacture and the need to join the own competencies with other entities' competencies to cover the entire value-chain.

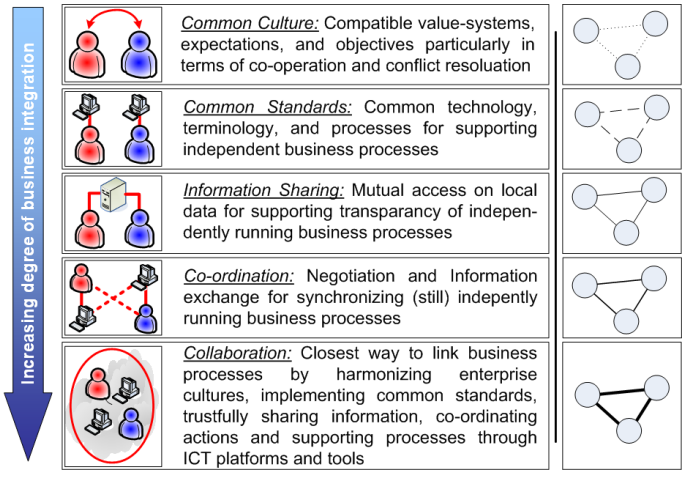
A set of co-operating business entities is called a "business network". Actors in those networks are individuals or groups/ organizations of individuals (for instance teams, enterprises, and networks of enterprises) [Wassermann; Faust 1994]. Nowadays, academia and industry claim the need for business network concepts and models that are focusing on the individual actor. Emerging models like the Professional Virtual Community (PVC) are dedicated to these needs [Crave; Ladame 2005].

Modern concepts in business networking are explained by the European Integrated Research Project ECOLEAD (European Collaborative Networked Organizations Leadership Initiative, IP no. FP6-505869; www.ecolead.org).

### Collaboration as key-enabler to successfully networking in business networks

All these concepts share the aspect of collaboration. According to Steven Alter, collaboration is to be seen as the ultimate step in synchronizing two or more partner's business activities. As prerequisites, it requires implementation of the sequence of harmonizing the different actors' cultures and value systems, implementing common terminologies and standards, exchanging information and knowledge, and co-ordinating the actors' individual processes for leveraging efficiency of joint business [Alter 2001]. In that sense, collaboration creates an environment in which human actors temporarily or permanently can merge their processes for performing joint business. Communication between the human actors is strongly supported by Information and Communication Technologies (ICT) that create a virtual mirror-image of the human interactions.

*Figure 2: Stepstones in Business Integration [according to Alter 2001]*




### The role of knowledge in innovation processes

As stated in the introduction, the success of an innovation stands and falls with the efficiency of gaining new knowledge from R&D and with the efficiency of incorporating this new knowledge into new products, services [Romer 1990], or Extended Products. According to Nonaka and Takeuchi, knowledge is information interpreted and coloured by the individual's personal experiences, feelings, and background [Nonaka, Takeuchi 1995]. The present role of knowledge in the production process is analyzed by Peter Drucker by the concept of the "knowledge worker" [Drucker 2001]: A knowledge worker possesses highly specialized and personalized knowledge and, subsequently, cannot be replaced by other workers haphazardly. So it is the individual worker who is sharing its individual or company-based knowledge throughout the innovation process, and, consequently, we consider the individual worker as node in the innovation network. Additionally, putting individuals as nodes in the innovation networks facilitates integration of freelancers into the network.

## AN APPROACH TO DISTRIBUTED INNOVATION MANAGEMENT IN ENTERPRISE NETWORKS

Based on our previous research we presented a model for managing Distributed Innovation Processes in networks of enterprises [Eschenbächer et al. 2005]. The approach is based on a Stage-Gate-schema breaking-down the innovation process into five stages (i.e. phases) and four gates representing reviews that either open the door to the next stage, or push the innovation process back into the previous phase:

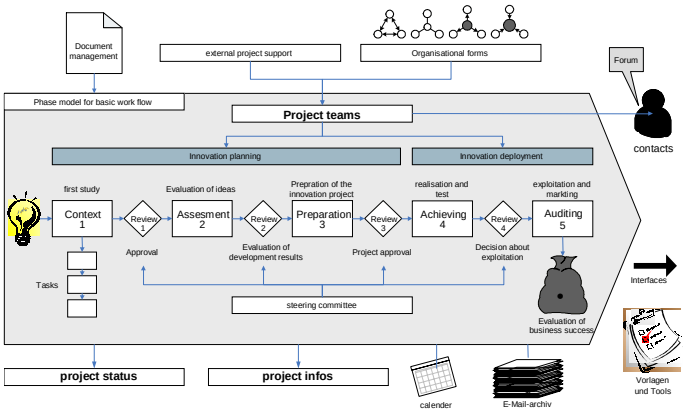
1. *Context:* Development of innovation ideas in the respective team's context and circumstantial parameters
2. *Assessment:* Assessment of the developed ideas especially regarding their feasibility
3. *Preparation:* Planning the innovation project
4. *Achieving:* Implementing the project schedules, developing, and testing the solution/ innovation
5. *Auditing:* Validating the results/ innovative solution, and introducing it to the market

These processes are incorporated into a technical framework describing a set of technical components and specifications to support Distribute Innovation Management processes by Information- and Communication Technologies.

### Application Area and Model Assessment

The model outlined above provides a first approach for Distributed Innovation Management in collaborative networks of enterprises, providing all the functionalities and tools to support collaboration between enterprises in innovation processes. It gives clear guidance on how to plan, implement and execute the innovation process, and provides a rich set of functionalities supporting exchange of information throughout the entire process. The entire model is incorporated into a web-based portal supporting virtualized innovation activities. The platform has been implemented in test-cases and was successfully evaluated by a group of lead-users.

*Figure 3: Management of innovation processes in collaborative networks [Eschenbaecher et al 2004]*




Recapitulating, this model built on the paradigm of company-based inter-organisational Innovation Management. Consequently, …

- …it is not specifically designed for worker-centric Innovation Networks,
- …it focuses on the organisation with a collaborative network perspective and not on the individual worker
- …it does not take into consideration issues like creativity management, social network theory/ analysis, and other facets that are desperately needed for explaining innovation networks on the level of the individual worker.

On the other hand, it clearly indicates that innovation management concepts must integrate the elements organization, processes, and technology.

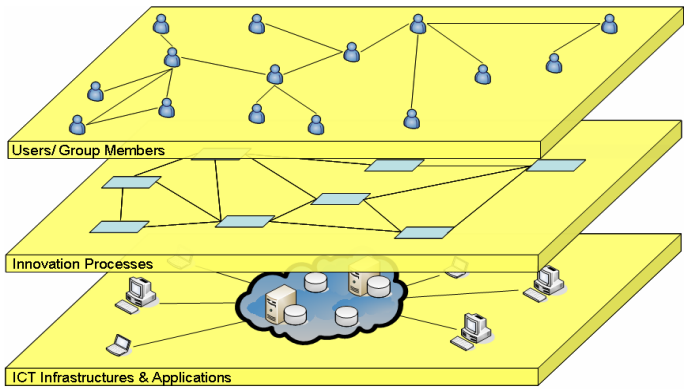
## RESEARCH CHALLENGES TOWARDS WORKER-CENTRIC INNOVATION NETWORKS

### Shaping collaborative worker-centric Innovation Networks

As a starting-point for drawing a conceptual outline of worker-centric collaborative innovation networks we will adopt the trinity of organizational structures, processes, and technology to the specific needs of these networks.

- *Structural models.* Worker-based Innovation Networks are large-scale social networks. In this context, two mechanisms in creating these networks are thinkable: First, controlled configuration; i.e. there is a co-ordinating actor inviting selected partners for participation in the Innovation Network. Invitation must be based on the competencies a potential partner can offer and on best matches between required and offered competencies. Most industrial R&D projects are based on the co-ordinated approach. Second, the network is self-organized; i.e. members can join or leave the network at their own will. This creates a democracy-oriented network, for instance in Open-Source software development.
- *Collaboration Mechanisms in Innovation Activities.* In Innovation two principles in organization collide: On the one hand side, innovation is a structured process that must be bound to certain generic stages to be successful (structured elements). On the other hand, innovation is a creative process that must leave its actors enough space and freedom to let creativity flow without being misrouted or compelled by the ordered elements within the innovation process (chaotic elements). This raises two requirements to innovation processes in large-scale networks: first to implement mechanisms that facilitate management of collaboration between different entities; second, to set and optimize parameters for collaboratively creating innovative solutions in a self-organized manner. The significance of involving large groups in decision-making vs. involving a few only is presently recognized by science, but not yet explained for mechanisms in collaborative innovations [Surowiecki 2004].
- *ICT tools and infrastructures.* As stated in the previous chapter, Information and Communication Technology (ICT) is a key enabler to success in nowadays networked business [Nagel 2005]. Innovation Networks require a suit of software components and underlying ICT infrastructures that are specifically designed for the need of quickly establishing and operating them. For instance, components to support competence identification, plug-and-play connectivity for network partners, collaborative Product Development, virtual prototyping, etcetera are needed. Developing these tools requires a sound set of underlying management concepts, thus we conceive ICT development as a later stage of development, prioritizing the development of structural models, and management methodologies.

*Figure 4: Layers in Collaborative Worker-centric Innovation Networks*




Considering these elements, we propose a three-layer approach as reflected by Figure 4. Understanding and modelling collaborative worker-centric Innovation Networks requires in-depth models on interactions among and between the model's layers. The layer of Users and Group Members reflects the structural properties of the Innovation Network, the layer of Innovation Processes comprises all the collaborative mechanisms and activities that are needed to lead the risky innovation endeavour to a success, and the layer of ICT Infrastructures and Applications outlines the required technological to run the Innovation Network despite huge geographical distance between its actors.

Elaboration on research challenges towards collaborative worker-centric Innovation Networks is to be structured according to this schema:

1. *Structural Models:* On the level of network structure, worker-centric Innovation Networks can be conceived as social networks that comprise three classes of actors: The company-based worker, the freelancing worker, and the customer. These actors are attributed by their different backgrounds and roles in the innovation process. While enterprise networks mostly are characterized by a limited number of nodes, networks of individuals reach structural properties of Small-World Networks utilizing well-connected actors for involving remote competencies.

Summarizing these considerations and challenges we state that the following research questions must be addressed and answered on the way towards a consistent approach to collaborative worker-centric Innovation Networks:

- To what extent can social network theory/ analysis contribute to conceive and explain the phenomenon of worker-centric innovation networks; and how can it support development of management methodologies?

- Can Innovation Networks be conceived as a new manifestation of the concept of Communities?
- How can emerging concepts like the Professional Virtual Communities (PVC) act as a basis for conceiving and explaining worker-centric innovation networks?
- How do structural properties of the Innovation Network influence the way they are managed and vice versa?

2. *Collaboration Mechanisms in Innovation Activities:* Basically, in collaborative worker-centric Innovation Networks, the following classes of actors are involved:

- *The company-based worker:* Most workers today are embedded in organizational structures and hierarchies. With that they do not deal with their own knowledge but with knowledge that is owned by the company they work for. Nevertheless, those company-based workers act as individuals in the innovation networks and collaborate according to the rules of (i) their company, and (ii) the network. This requires trade-off mechanisms and flexible and adaptive interaction patterns.
- *The freelancing worker:* Freelancing workers are not restricted by the rules of a company in which they are embedded. Thus, rules for contracting, knowledge sharing, and principles of collaboration are within their own estimation allowing them a larger number of degrees-of-freedom. Instead they have their own personal value-systems that normally are more flexible than those of a company. Nevertheless, within a collaborative Innovation Network, those freelancing workers must synchronize their own personal value-systems to those of the other collaborating entities within the network.
- *The customer:* Recent studies clearly indicate that innovation is getting increasingly customer specific, conceiving the customer's desires and requirements as triggers for development of innovative products and services [Kröhner 2005]. This leads to an increasing level of democracy in innovation activities both in terms of customer integration (customization of innovative solutions) and in terms of balancing rights and obligations among the entities engaged in the innovation activities [von Hippel 2005]. Assuming the customer as the trigger of innovation processes, the customer must also be integrated as a node into the innovation network. Interaction between the customer and the nodes executing the innovation on the customer's visions comprises for instance customer-focused requirement definition and analysis, collaborative product-/ service engineering processes, order tracking by the customer, and review/ evaluation mechanisms.

Interactions between those entities are complex and require both goal-oriented management and a creative chaos to be efficient. In developing collaboration mechanisms the main research challenges are related to the need of balancing organization and chaos in the innovation network:

- How and where to draw the borderline between (i) structured processes and management and (ii) self-organization and chaos in the Innovation Network?
- Is it possible to transfer inter-company processes in distributed innovation management to the network granularity of individual actors; and which adaptations need to be made?
- How can natural processes, especially the behaviour of swarms and group dynamics support collaboration within and management of innovation networks?

3. *ICT Tools and Infrastructures:* Specifying ICT support for collaborative patterns and mechanisms within Innovation Networks is probably the most challenging endeavour in the context of this paper. For precisely specifying what is needed the underlying principles and mechanisms must be known, and at the present state of research, these principles and mechanisms are in their infancies. On a high level, the following challenges must be addressed:

- Building-up a platform that bridges the geographic distance between the actors, and creates a virtual mirror-image of their real-world collaboration
- Specifying and developing a secure and trustful plug-and-play environment, that is flexible enough to be adapted to the specific needs of the Innovation Network
- Defining, specifying and developing services and applications supporting characteristic processes in innovation networks, for instance competence search for network configuration, knowledge exchange among partners, collaborative product development, and setting-up and running virtual laboratories.

## CONCLUSIONS

The intention of this paper was to wrap-up our research on what is needed to explain, model, and manage collaborative worker-centric Innovation Networks. The research challenges as stated do not claim to be exhaustive, and several more could be thought of. Anyway, it got obvious that fulfilling these needs requires wide and multidisciplinary research in which experience from business management, engineering, computer science, social science, complexity science, psychology, and many more disciplines must be incorporated.

Following that road also requires joint efforts by industry and academia: industrial models must be built on a sound theoretic fundament to solve the problem as a whole; just as academia cannot develop promising and operable models, theories and concepts if they are not embedded into a clear and well-defined industrial context. In the end, both parties could take advantage: academia will get insight and in-depth knowledge in a field that is clearly crucial for production systems in the future; and industry will get management models and technologies at hand that will help them to withstand competition in the upcoming age of innovation.

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