Design Constructs for Integration of Collaborative ICT Applications in Innovation Management

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Abstract. This research paper presents considerations on design constructs which can be beneficial to integration of collaborative ICT applications for innovation management. The paper draws directly on developments of an ongoing broad initiative funded within the European Commission's 6th Framework Programme in the area of new, multi-functional materials and processes. Purpose of the paper is to illustrate how collaborative ICT applications for innovation management in enterprise networks can be conceptually integrated with help of a design approach using specific constructs. Implementations within eight cross-sectoral manufacturing networks of small and medium sized enterprises suggest simplified integration through the use of the presented design constructs.

Keywords: collaborative ICT application, innovation management, cross-sectoral manufacturing networks.

1 Introduction

The fusion of industries is a phenomenon, which has increasingly been perceived in the recent two decades [1]. The term refers to the circumstance that industries enlarge their sectoral boundaries and extend their range of products and services to other sectors, which leads to convergence effects in the areas of technology, markets, as well as regards regulatory, standardization and institutional aspects [2].

However, it is only recently that research on innovation management has recognized this as imperative research topic, in front of the challenges European firms in "traditional" industrial sectors, like textile and clothing, shoe, furniture, and others, are facing. Against the background of globalization pressures, these industrial sectors are urged to extend their accustomed industrial boundaries, and target at new (emerging) markets. Cross-sectoral industrial networking, with the aim to create new, high added value products and services, has become an emerging paradigm answering to the growing complexity of today's rapidly changing business environments in an evolving innovation economy [3]. In order to create innovations, firms need to combine their complementary core competencies across sectors, and share highly specialized knowledge about new materials, their properties, and new processing procedures. Peculiar problems arise, when formerly separated, industry-specific paradigms are fused with each other, regarding for instance knowledge sources, organization of innovation activities, or fundamental technologies.

As they are characteristic for traditional sectors, in particular small and medium sized enterprises (SMEs) require becoming pro-active network partners for the co-operative development, manufacturing, marketing, and recycling of products and (integrated) services.

The resulting collaborative innovation and production networks are consequently forced to come up with adequate methods and instruments for handling knowledge as well as for innovation management. Consequentially, at the core of innovation management research in this domain, is the question for new (holistic) management concepts with the aim to create knowledge-based and knowledge-driven networks. In particular, specific challenges are resulting for the introduction of appropriate information and communication technology (ICT) systems and infrastructures for strategic innovation [4], as well as regarding management of collaborative innovation processes.

A prerequisite for building such networks is the establishment of e-collaboration infrastructures to enable methodological and ICT support of innovation activities in the networks. Such infrastructures must provide appropriate functionality (applications/services) to support the ongoing innovation activities in a systematically structured and integrated manner across sectoral limits.

In this paper we consider in particular ICT applications extending the functionality of Enterprise Resource Planning (ERP) systems, in an innovation context as outlined above. We present some design constructs to create collaborative ICT applications in this context and to support their integration. Implementations within eight SME manufacturing networks provide a case basis for a first evaluation of the created applications and the effort required for their integration. The considered innovation networks were established in the framework of the AVALON European Integrated Project for SMEs [5].

First, we present the design idea of the constructs and their implications on integration of applications (chapter 2). Then a short recapitulation of experiences from practical implementations of these constructs is given (chapter 3), as well as a summary (chapter 4).

2 Design constructs

2.1 The construct of innovation subject

A primary question which has been tackled by our research was which core elements are underlying innovation activities in general. What kind of objects does innovation deal with? We have consequently identified four elements as ***primary subjects of innovation***: Material, (Manufacturing) Process, Resource, and Idea.

Those subjects can be considered as distinct, general ***classes*** of objects, innovation deals with (or *subject classes*). As we have validated in a couple of implementations, in general all activities operatively related to innovation in manufacturing can be related (back) to those classes of subjects.[1]

These innovation subject classes can be further specified, using the context of the real-world innovation object: For the value added stages relevant in a specific sector, specified *subject types* can be defined, e.g. in textile industries, on the stage of fabric creation, a material type “woven fabric”. Such types can be instantiated to represent existing real-world objects (*subjects*).

In other words, this is an object-oriented analysis and design approach, deploying a *class model*, allowing for a classification, and typing of real-world innovation objects [6]. Properties of subjects are created as attributes of the subject types.

We have found this approach appropriate for the context of a cross-sectoral network, as accustomed material or resource hierarchies widely fail, e.g. due to the circumstance that new types of materials are processed on machines in a new context. In such cases, the properties (attributes) of objects can often not be maintained in existing ICT systems because of their specialization to an industry sector. The presented approach is independent of both, industry sector, and application/use of a subject.

2.2 The construct of innovation knowledge item

In the following paragraphs we present an approach to design collaborative ICT applications for innovation management, which hyperlinks back any activity to those basic innovation subjects.

In general, innovation activities which are not related to specific innovation methodologies (like e.g. Quality Function Deployment/QFD) can cover for instance: documenting findings on a subject (ad hoc), sharing knowledge on a subject with experts in the network, publishing findings to network partners, discussing issues with experts to find problem solutions, carrying out simple collaboration activities with another partner (e.g. material testing tasks), and many others more. All of these activities might include a specific set of subjects, for instance an idea, a material, and a process, in order to discuss the idea, whether the material can be transformed by a certain process. While in this case the subjects are defined, it is necessary to link them technically, and to comment this activity, in order to create a representation of it in the ICT system(s)/application(s). This integrative element can be implemented in form of an “***entry***” functionality (implemented as a further class object), which allows for an establishment of (an arbitrary number of) relations to the various subjects involved, and to other entries (i.e. other activities) as well.

In our research work we have implemented this entry functionality as basic building block for a number of applications, converting ad hoc activities into simple work flow-based applications. This allows for a trace-back of activities to existing physical data sets. For this implementation of what could be called ***basic innovation***

[1] It must be mentioned for reasons of completeness that these subjects focus on objects of innovation relevant for our research work – related to manufacturing networks. Of course also organizational structures could be regarded as innovation subjects, “organization” or ”business process”, or others. This kind of innovation is however not focused here.

services, network partners are provided supportive applications to activities like the ones outlined above (Tasks, Documentations, Issues,…).

Each activity carried out is represented in the ICT system by an entry, accordingly. The entry thus may be considered as instance of the ***Innovation Knowledge Item (IKI)*** design construct.

An entry may be assigned status information, if it is to be further developed by a work flow application implementing an innovation method like for instance QFD. Further, it is to be stated, whether the entry can be assigned to specific users or projects, in order to define its confidentiality (see Figure 1).

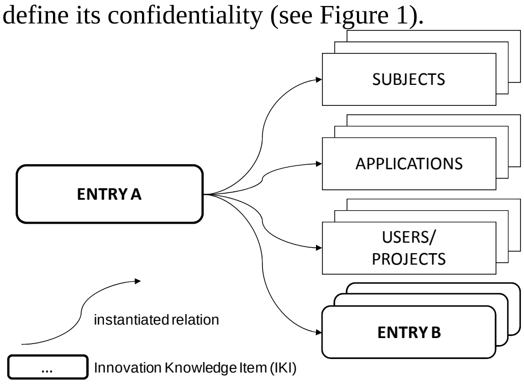

Fig. 1. *Innovation Knowledge Item (IKI)*

2.3 Implications on application design

What implications do the constructs of subject and Innovation Knowledge Item (IKI) impose on application design?

An IKI is principally independent from status, but an integrative object, it can serve as input for structured processes (implementing innovation methodologies) as well as for further ad hoc development of the subjects considered by the IKI. Ideally, all knowledge required is contained already in the relationships of the IKI (which however depends on the innovation methodology followed).

Regarding issues of migration, respectively mapping of knowledge structures, the IKI provides the relevant relations to existing knowledge structures of involved subjects. Those relations, or the related data respectively, will serve as inputs to an innovation methodology's systematic procedure. Eventually, further knowledge will be created during application of an innovation methodology, and additional attributes and content will be created within or in addition to the related subjects' data structures (not in the existing entries).

During innovation activities, there might also arise the need to extend, or to limit knowledge structures handled within an innovation activity: In parallel to the argumentation above, the construct of subject allows, within a specific application, to relate to only those attributes of subjects, which are relevant. Subject attributes can be added as imposed by the particular activity/methodology (added to the subjects, not the entries), because subject attributes can be extended.

2.4 Implications on integration of applications

What consequences can now be drawn from the presented constructs for the integration of ICT applications for innovation management in manufacturing networks? A principle architectural structure for interoperation of ICT applications, can distinguish in between *Basic Innovation Services*, and services implementing innovation methods, *Professional Innovation Services*, as outlined in Figure 2. Innovation Knowledge Items (entries relying on subjects) provide the basic constructs to transfer knowledge structures and to give procedural support to configuration of dedicated innovation methods. As an exemplary case, an IKI A, which might have been created as part of an ad hoc activity (Basic Innovation Service), is put into the context of a concrete innovation method (e.g. QFD), and is thus constituting a new item IKI A*, which is configuring the corresponding Professional Innovation Service (IKI A → IKI A*). On the contrary, linking back from a Professional Innovation Service is always enabled through the IKI construct allowing for entry creation independent from process (work flow) structures.

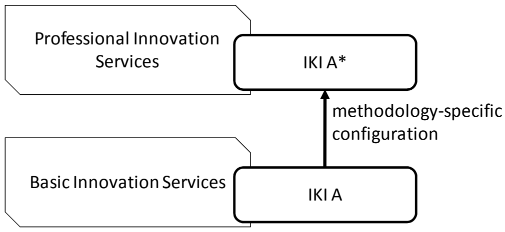

Fig. 2. Architecture principle of ICT application interoperation in innovation management

3 Experiences from practical implementations

The constructs of subjects and IKIs have been implemented in our applied research work in form of relational data base structures. The described Basic Innovation Services as well as a number of Professional Innovation Services have been implemented as work flow-based applications on an e-collaboration platform, making use of the presented constructs.

Within eight cross-sectoral manufacturing networks of SMEs (with around five partners each), these applications are currently in use in an industrial environment, with each network pursuing its own innovation objective (e.g. development of new products, or manufacturing/material testing processes). The “subjects” created so far within the implemented applications are representing various new unprecedented data structures, especially in the area of hybrid textile materials, which are used for applications in a couple of different sectors (medical devices, automotive, aerospace and others). The developed approach supports the seamless transition from ad hoc to “determined”, i.e. methodologically supported activities. Integration efforts are hereby considerably reduced, which allows for application in an SME networking context.

The basis application realizing the described constructs for Basic Innovation Services is the Innovation Project Management (IPM) application, which allows for collaborative documentation, discussion (e.g. issues tracking), project management (e.g. task management), and further functionalities. It provides work flow support for ad hoc innovation activities.

Currently, the number of applications regarding Professional Innovation Services, as distinct applications for systematic innovation management methods, is extended, covering at this moment applications for Quality Function Deployment (QFD), Failure Mode and Effects Analysis (FMEA), Product Potential Analysis (PPA) and diverse functionalities for Life Cycle Analysis (LCA) and Intellectual Property Rights Management (IPR).

4 Summary

In this paper we have presented an approach promoting an integrative design of ICT applications for innovation management in cross-sectoral manufacturing networks. The construct of *subjects* returns to the very roots of innovation activities, and allows for the creation of *Innovation Knowledge Items (IKIs)* helping to recapture the sequence of performed innovation activities. The constructs provide a basis for integration of *Basic* as well as *Professional Innovation Services*. Further research is required on tracing back and understanding the context of ad hoc innovation activities.

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