Informationsmanagement und Computer Aided Team

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Tool-Supported Innovation Management in Service Ecosystems

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RESEARCH

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Herausgegeben von Professor Dr. Helmut Krcmar

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Christoph Riedl

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With a foreword by Prof. Dr. Helmut Krcmar

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RESEARCH

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Foreword

In today's economies, services play an important role contributing to around 70% of the gross domestic product of developed countries. Many of these services are traded and delivered online giving rise to the "Internet of Services" and "Service Ecosystems." Here, innovation plays a crucial role due to short product cycles. To achieve the required capabilities, organisations increasingly open their innovation processes to allow an inflow of ideas from outside the organisation. Companies increasingly turn to their customers, suppliers, and other external actors to collect ideas for new products and services. This approach has been termed "Open Innovation" and has become an established business practice and a popular research issue. However, many open innovation practices are not as successful as they are hoped to be. Opening innovation processes to external input places additional requirements on innovation management capabilities such as tracking ideas from multiple sources across multiple systems. Furthermore, it is not completely clear how tools to support the resulting innovation communities should be designed.

Encouraged by current challenges of implementing open innovation practices in networked organisations such as service ecosystems, this work investigates how tool-supported innovation management can be achieved. Grounded on the current body of knowledge of new service development, open innovation, and service ecosystems, it develops a framework for tool support including data structures, architectural designs, and prototype instantiations. Based on these insights, the work proposes design recommendations to help organisations implement IT support for their open innovation activities. The design recommendations are rigorously evaluated using multiple methods of design research, including a field experiment with 313 participants.

Christoph Riedl's work shows, for example, that common methods of community-based idea evaluation using simple promote/demote rating scales do not adequately reflect idea quality and methods such as multi-attribute rating scales should be used instead. Thus, he provides valuable design guidelines and recommendations, both on the feature level as well as on the overall system level.

This work is an important contribution to the research field of managing information systems. The work appeals by its broad scope of theory, multi-method background and approaches, and its rigorous design evaluation. Researchers of information systems will gain new insights on which research methods and theories are applicable to support online innovation communities. For practitioners, it provides recommendations for developing successful tool support to implement open innovation activities.

I recommend this book as a valuable reading and resource. It provides new and promising insights into an emerging research field and inspires different kinds of readers, researchers and practitioners alike, to adopt a new perspective on innovation management in information systems.

Prof. Dr. Helmut Krcmar

Acknowledgement

Whilst a PhD is intended to be a contribution by one person, it is really the combined efforts of a number of people. In my case, this PhD journey has been guided and significantly contributed to by the following people whom I want to thank.

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This research was conducted in the context of the THESEUS/TEXO project,[1] funded by the the German Federal Ministry of Economics and Technology (BMWi) under grant code 01MQ07024. (The responsibility for the content of this publication lies with me.) I am grateful for the support provided to me by the grant.

I owe special thanks to my friends Gerrit Schlingermann, Wolfram Möbius, and Dominikus Baur for proofreading and correcting many chapters of this thesis and constructively failing to understand the poorly written parts. Thanks also to my housemate and good friend Ahmad Ahmadi for making it worth going home.

Finally, I would like to thank my parents and my sister for all their continuous support.

Cambridge, Massachusetts, April 2011 Christoph Riedl

[1] `http://www.theseus-programm.de/anwendungsszenarien/texo/default.aspx`

Abstract

Problem Electronic services delivered over the Internet are gaining importance in the business world giving rise to the study of the "Internet of services" and "service ecosystems." Approaches of new service development (NSD) that prescribe systematic ways of developing services of all kinds, seem deficient in addressing many of the challenges and opportunities arising from electronic services delivered through open platforms. By analysing the differences between traditional NSD and the development of electronic services, this research conceptualises, designs, and develops tool support for innovation management in the context of service ecosystems.

Research Method Following the design science paradigm this research uses theory-driven design to develop concepts for tool-supported innovation management for electronic services in service ecosystems. To evaluate selected aspects of the designed artefacts, this research uses multiple methods including a Web-based experiment, a controlled laboratory experiment, and questionnaires.

Result A key result is the Idea Ontology, a Semantic Web-based approach of a common language to enable information sharing and to foster interoperability between innovation management tools. The proposed ontology captures both a core idea concept and further concepts to support collaborative idea development, including rating, discussing, tagging, and grouping ideas. Regarding the use of rating mechanisms our findings show that simple rating mechanisms such as thumbs up/down rating or 5-star rating do not produce valid idea rankings and are significantly outperformed by a multi-attribute scale. Furthermore, we introduce the notion of ad-hoc establishing shared artefacts thus supporting a shift from the mere collection of independent contributions to collaborative idea development.

Research Implications This work contributes to open innovation research by extending the currently dominating focus from that of a single firm to that of a network of actors bound together through a central platform. Furthermore, it contributes to the study of innovation portals supporting an online innovation community in collaborative idea generation through the use of duplicate detection and idea selection through idea rating mechanisms. This work contributes to theory by demonstrating how theories can be used to guide design decisions to build better systems.

Practical Implications The system design and design principles developed in this work can guide future developments to provide tool-supported innovation management in service ecosystems and, in particular, innovation portals supporting an online innovation community. Specifically, our research provides actionable design guidelines for community-based rating mechanisms, and for establishing awareness of previous contributions which allows channelling individual efforts in innovation portals.

Originality The specific contribution of the Idea Ontology is the description of the technical architecture in which an ontology-based approach can be applied to achieve interoperability, re-use, and structure in an inherently unstructured field. Furthermore, we offer insights into how different rating mechanisms for idea selection work within the context of online innovation communities. We also presented a novel use of clustering in the idea generation process in the context of online innovation communities.

Contents

List of Figures

List of Tables

List of Listings

List of Abbreviations and Acronyms

AJAX .... Asynchronous JavaScript and XML
ANOVA .... Analysis of Variance
API .... Application Programming Interface
ATM .... Automated Teller Machine
BMBF .... Bundesministerium für Bildung und Forschung
BMWi .... Bundesministerium für Wirtschaft und Technologie
CAD .... Computer Aided Design
CRM .... Customer Relationship Management
CSCW .... Computer Supported Cooperative Work
DR .... Design Rationale
DSS .... Decision Support Systems
ER .... Entity-Relationship
ESS .... Executive Support Systems
FOAF .... Friend of a Friend
GDSS .... Group Decision Support Systems
GSS .... Group Support Systems
GUI .... Graphical User Interface
HCI .... Human-Computer Interaction
HTML .... HyperText Markup Language
IBIS .... Issue Based Information Systems
ICT .... Information and Communication Technology
IM .... Instant Messaging
IP .... Intellectual Property
IS .... Information Systems
IT .... Information Technology
NPD .... New Product Development
NSD .... New Service Development
OECD .... Organisation for Economic Co-operation and Development
OWL .... Web Ontology Language
OWL DL .... OWL Description Language
R&D .... Research and Development
RDBMS .... Relational DataBase Management System
RDF .... Resource Description Framework
RDFS .... Resource Description Framework Schema
REST .... REpresentational State Transfer
RIA .... Rich Internet Application
RPC .... Remote Procedure Call
RPC .... Reverse Product life-Cycle
RQ .... Research Question
RSS .... Really Simple Syndication

SDK .... Software Development Kit
SFDC .... Salesforce.com
SIOC .... Semantically-Interlinked Online Communities
SKOS .... Simple Knowledge Organisation System
SME .... Small and Medium Enterprises
SOAP .... Simple Object Access Protocol
SPARQL .... SPARQL Protocol and RDF Query Language
SQL .... Structured Query Language
SUTVA .... Stable Unit Treatment Value Assumption
UI .... User Interface
UML .... Unified Modeling Language
URI .... Uniform Resource Identifier
URL .... Uniform Resource Location
USDL .... Unified Service Description Language
VSM .... Vector Space Model
W3C .... World Wide Web Consortium
WSDL .... Web Services Description Language
XML .... eXtensible Markup Language

Chapter 1

Introduction

[C]ompanies that don't innovate die
Chesbrough (2006b) xvii.

At the beginning 20th century Schumpeter (1934) identified innovation as expression of entrepreneurial spirit, the reason for economic growth, and business activity. Thus, he articulated the value creation potential of innovations (Schumpeter, 1934). This is supported by a number of studies that show that successful companies derive up to 80% of their turnover with products younger than five years, thus placing increased emphasis on innovation (Cooper/Kleinschmidt, 1995; Kim/Mauborgne, 2004). Along with shifting the value chain towards low-wage countries and rationalisation, innovation is considered a core driver of business growth.

Innovation is especially important in the area of services[1] where it is strongly related to firm performance (Eisingerich/Rubera/Seifert, 2009). Throughout the world the focus on services is increasing, both from a business perspective as well as from a research point of view. Services are of an increasing importance to our society and represent a significant share of most of the world's largest economies. Nearly 80% of all employees in western economies work in the service sector (Ostrom et al., 2010). In China, more than 40% of the gross domestic product are now attributed to services. In many other leading economies services account for over 70% of their gross domestic product (Ostrom et al., 2010). Consequently, our need to understand service as a science has never been greater (Lemon, 2010, 3). An increasing proportion of these services are today delivered online, or are at least traded and accessed through electronic networks. Novelty and innovation is even more important for electronic services due to faster cycle times and is considered a key source of value creation in e-business (Amit/Zott, 2001).

This increased economic focus on services together with recent technological developments in the area of service-oriented architectures and Web services lead to the formation of a new kind of business networks and value exchange. In particular, in the area of electronic services the emergence of the cloud computing concept, together with the vision of a future Internet of services and service ecosystems pose an exciting new area for business research in general and the analysis of networked business relationships in particular (e.g., Schroth,

[1] We review definitions of the term "service" and related concepts in Section 3.1. In this introduction the term "service" is used in a general sense.

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2007; Barros/Dumas, 2006). Within these networks, new services can be formed simply by plugging together existing services and creating mash-ups. Open platforms for services like Facebook, Google, salesforce.com, and the Apple App Store for the iPhone emerge that promise easy development, distribution, and delivery of electronic services leading a general trend towards "platformisation" (e.g., Zittrain, 2008; Cusumano, 2010b). These platforms depend to a high degree on complementary innovation to be useful (Gawer/ Cusumano, 2008; Boudreau/Lakhani, 2009).

Approaches of new service development (NSD) that prescribe systematic ways of developing services of all kinds, seem deficient in addressing many of the problems and opportunities arising from electronic services delivered through open platforms. How can the constraints of electronic services like fast cycle times be addressed? How can the design opportunities offered by electronic services like transparent service feedback be incorporated in a systematic way? How can the networked character of service delivery encountered in these service platforms be extended to the innovation phase? This culminates in the question by Menor/Tatikonda/Sampson (2002, 147)

> "Is there a 'new' NSD process for Internet service [...]?"

Or, as Williams/Chatterjee/Rossi (2008, 505) put it

> "Is there a science behind designing *digital* services?" (emphasis added).

The aim of this research is to develop concepts and tool support for innovation management in open service platforms and thus to answer the question how Internet services can be developed. The work explores the aspects in which electronic services differ from non-electronic services and proposes concepts for collaborative service development within a network of actors. The research builds on new service development research and addresses the gap of developing new Internet services. It focuses in particular on aspects related to networked innovation resulting from the emergence of open service platforms.

1.1 Problem and Motivation

Today, the insight of Schumpeter (1934) is more relevant than ever and the competitive importance of innovation is well established (Tidd, 2000). Innovation is acknowledged as a key factor for personal, professional, social, and economic development by the Federal Ministry of Education and Research (BMBF) of Germany demanding further advancement (without author, 2009b). Likewise, the National Science Foundation of the United States has started similar support programs focusing on innovation research (e.g., without author, 2010a). Innovation has been declared "imperative" from 2009 to 2013 by Gartner (without author, 2009c) and the "holy grail of 21st-century business" by McKinsey analysts (Berwig et al., 2009, 1). The importance of innovation is recognised by leading economic and government organisations including the Organisation for Economic Co-operation and Development (OECD), the European Commission, and the BMBF (de Backer, 2008; Hidalgo/Tiscar, 2004; without author, 2009b).

Especially in the important area of services where, as noted above, over 70% of the gross domestic product of leading economies is earned, innovation is a key criterion for success and economic growth. The German Federal Ministry of Education and Research announced a plan of action aiming at forming the future through services. Here, service innovation is at the core of the high-tech strategy for the year 2020 (without author, 2009d). As Maglio et al. (2006, 81) put it: “The global economy is a large service system in need of innovation to grow.” This constitutes a gigantic shift from product-based economies to economies based on services (Williams/Chatterjee/Rossi, 2008).

The intersection of service research and innovation research poses a very exiting and relevant area for research (Lemon, 2010). In a lead article of the *Journal of Service Research* Ostrom et al. (2010) propose research priorities for the future of service research. The list includes 1. stimulating service innovation, 2. enhancing service design, 3. optimising service networks and value chains, and 4. enhancing the service experience through co-creation (Ostrom et al., 2010).

Service research encompasses many disciplines and perspectives that can contribute to our understanding (Chesbrough/Spohrer, 2006; Spohrer et al., 2007). Taking a broad view, Ostrom et al. (2010) suggest that service innovation creates value for customers, employees, business networks, and communities through new and improved service offerings, service processes, and service business models. However, much research is needed to understand key issues in the service domain and to develop new models and new knowledge to improve the science of services (Lemon, 2010). In the area of service research specifically digital or electronic services are of increasing focus (Williams/Chatterjee/Rossi, 2008). This is a result of the widespread availability of computers and the pervasive Internet which form a digital infrastructure that is capable of providing digital services in new and different ways (Williams/Chatterjee/Rossi, 2008). A European Commission trend report for 2010-2020 predicts the “Internet of X” referring to an *Ubiquitous Internet Society* with *X* encompassing concepts like “Internet of Services,” “Internet of Things,” and “Internet of People” (Cave et al., 2009). This highlights the particular importance of electronic services in a networked and interconnected world of open standards and innovation (Cave et al., 2009).

The capability to innovate is becoming more important for organisations as shorter product life-cycles, increased competition, changing customer behaviour, and technological progress force them to compete in rapidly changing markets (e.g., Gallouj/Weinstein, 1997; Fine, 2000; Carrillo, 2005; Leimeister/Glauner, 2008; de Backer, 2008). Consequently, the management of innovation and new service development is a prime concern for companies. Innovation is even more important in the area of Web-based services where barriers of entry are particularly low, services can be copied easily, and technological advances are especially rapid (Menor/Tatikonda/Sampson, 2002; Zhang, 2008). Competitive advantage can only be achieved by companies through continuous innovation which leads them to new and improved services. To meet this challenge, organisations are looking for ways to enhance their capabilities to innovate. Organisations have long realised that innovation, like many business functions, "is a management process that requires specific tools, rules, and discipline" (Davila/Epstein/Shelton, 2006, xviii). Following this realisation organisations are looking at improving both their approach to innovation as well as their tool support for individual innovation tasks and the innovation process in general (Froehle/Roth, 2007).

New product development has been researched since the 1980s and new service development almost as long. However, major issues in that area remain still unsolved. In an exhaustive review of prior research Menor/Tatikonda/Sampson (2002, 140) conclude their section about new service development processes by proposing the following research objective: "Understanding the NSD process stages/activities and characteristics of successful NSD execution (e.g. degree of process formalisation, use of teams, etc.)." In addition to an unsatisfactory understanding of the general NSD issues the authors conclude that the emergence of the Internet and e-services further complicates issues of NSD (Menor/Tatikonda/Sampson, 2002). In addition to Internet services there are special limitations and opportunities regarding innovation that have not been researched. Aspects particular to electronic services like the compositionality of services and the platform character with an emphasis on re-use provide new and innovative ways of how new services can be developed within such an environment.

Service-oriented architectures and Web services have matured and become more widely accepted and used by industry. This growing adoption increased the demands for new ways of using Web service technology. Users start re-combining and mediating other providers services in ways that have not been anticipated by their original provider. Within organisations and cross-organisational communities, discoverable services are organised in repositories providing convenient access to component services that allow the creation of adaptable end-to-end business processes. This idea is captured in the term *service ecosystem* (Barros/Dumas, 2006). The same idea is also termed *Internet of services* (Buxmann/Hess/Ruggaber, 2009).

These developments allow a new degree of compositionality where new value-added services can be formed simply by combining existing services in innovative ways. This compositionality leads to even shorter product life-cycles, increased competition, changing customer behaviour, and technological progress. Consequently, the management of new service development is a prime concern for companies that want to conduct successful business in service ecosystems where competitive advantage can only be achieved through continuous innovation that leads to new and improved services. However, NSD in general and the development of new electronic services in particular remains among the least studied and understood topics and a clear research gap in service management literature can be identified (Menor/Tatikonda/Sampson, 2002). Furthermore, unique aspects of electronic services together with the development of service ecosystems are likely to influence the development of new services in a fundamental way.

Companies increasingly accept the importance of learning and increased knowledge flows. They move from a closed innovation model of internally developed ideas to an open model based on both internal and external sources of ideas and market channels (Chesbrough, 2006b). This open model of innovation emphasises knowledge flows rather than knowledge creation as the main driver of innovation (Bessant/Davies, 2007). Related concepts like increasing co-creation of value through customers, increased collaboration with experts, and using consumers as innovators have been identified as important business trends (Manyika/Roberts/Sprague, 2008; Bughin/Chui/Johnson, 2008). The move to a more open mode of innovation implies that more actors like customers, suppliers, and knowledge experts need to be integrated into the innovation process. With the increase in the number and type of participants involved in innovation projects, support for collaboration and communication has become more significant (Nambisan, 2003). This requires better

Research Context: THESEUS/TEXO Project

This research was conducted in the context of the THESEUS/TEXO[a] project supported by German Federal Ministry of Economics and Technology (BMWi). The goal of the THESEUS program is to establish a new Internet-based knowledge infrastructure to make better use of the existing knowledge on the Internet. The vision of THESEUS is to automatically bundle and link services on the Internet which nowadays only exist in isolation, for example, online shopping, flight booking, or enquiry services. The concept of the Semantic Web plays a major role in archiving this aim. In the course of the THESEUS program the necessary technologies are developed, tested, and evaluated according to specific use cases. The use case MEDICO, for example, covers relevant applications for semantic technologies in the medical domain. In contrast, the use case TEXO focuses on the creation of an infrastructure to simplify the combination and use of services on the Internet. Other use cases within the THESEUS program are ALEXANDRIA (knowledge platform for the Internet), CONTENTUS (media centres of the future), ORDO (organisation of a variety of digital information), and PROZESSUS (knowledge within companies).

Within the context of the TEXO use case, this research focuses on innovation aspects relevant to a future Internet-based knowledge infrastructure and tries to provide answers for the question how new services can be developed. In this context the *TEXO Innovation Repository* has been developed. The TEXO Innovation Repository has been designed as an open platform capable of integrating a variety of other applications. Several external tools have been integrated into the TEXO Innovation Repository developed by TEXO partners engaged in the work package "Service Innovation." The integration of the external tools will be described in more detail in Section 7.2. The integration of external applications serves as an important evaluation of the TEXO Innovation Repository and underlines the relevance of this research by pointing to a broader scope of application.

[a] `http://www.theseus-programm.de/anwendungsszenarien/texo/default.aspx`

tool support for integrating those actors, to facilitate the necessary communication and exchange of information, and for supporting the changed innovation processes. Technology in general has a positive influence on innovation (Chen/Tsou/Huang, 2009). IT support has consistently been found to have a major impact on the development of new services with regards to speed, quality, and the ability to support co-operation within innovation processes (e.g., Froehle et al., 2000).

Taken together the increased economic focus on services, the special requirements posed by developing new Internet services, the environment of service ecosystems, and the move to more open modes of innovation offer the potential for new and improved service innovation approaches that are until now little understood.

1.2 Objectives and Research Questions

Two paradigms characterise much of the research in the information systems field: behavioural science and design science (March/Smith, 1995; Hevner et al., 2004). Research following the behavioural science paradigm seeks to develop and verify theories that explain or predict human or organisational behaviour. Research following the design science paradigm attempts to create things that serve human purposes: to create new and innovative artefacts. Both paradigms are foundational to the IS discipline (March/Smith, 1995; Hevner et al., 2004; Gregor, 2006). The motivation for this research lies in the design science paradigm of IS research and makes use of a corresponding research approach (March/Smith, 1995; Gregor, 2006). For the arrangement of such an approach it is necessary to define the design artefact and the design goal (Chmielewicz, 1979; Simon, 1969).

The *design artefact* of this work is an instantiation of a concrete IT system. The design and development of IT systems is a subject-matter of *system development*, a core discipline of IS research (Nunamaker/Chen/Purdin, 1991). Concomitantly with the development of the concrete IT system, additional artefacts like constructs and models are necessary to support the development of the IT applications (Iivari, 2007). The IT system and accompanying artefacts developed in this research are summarised in the next section (Section 1.3).

The *design goal* of this work is to design the IT system and the necessary additional artefacts in such a way that the system can support the innovation management for electronic services in the context of service ecosystems. Based on the motivation above, it is necessary to identify the differences of electronic and non-electronic services, and to provide concepts that address these differences. Furthermore, it is necessary to address the specific aspects of networked innovation found in service ecosystems.

In summary, the aim of this research is to

- identify key requirements that need to be fulfilled to provide this tool support,
- contrive a useful approach for developing new services within service ecosystems,
- support the validity of the approach by reference to prior research and theories in the field of new service development, service ecosystems, and open innovation,
- demonstrate the feasibility of the approach through the development of an IT system that supports the key aspects of the approach, and
- provide support for the utility of the approach by an evaluation of the IT system.

Aim of this research Develop concepts for tool-supported innovation management for electronic services in the context of service ecosystems using the approach of networked and collaborative service innovation.

Following the design science approach of developing tool support for innovation management in service ecosystems, this research is structured along three research questions. First of all, it is necessary to systematically investigate the new service development process in the context of service ecosystems and networked innovation. Based on this investigation, requirements an IT system should address can be derived. Consequently, the first research question is:

RQ1 What are key requirements that need to be fulfilled to provide tool-supported innovation management in service ecosystems?

Answering this research question leads to a list of requirements that is informed by innovation specific aspects of electronic services, aspects of service ecosystems, and networked innovation. RQ1 is addressed through a literature review of new service development, service ecosystems, and open innovation related research.

Second, the requirements collected in research question one need to be transformed into a system design which can guide the development of an IT system to support innovation in service ecosystems. This leads to the second research question:

RQ2 What are design principles for a system design for tool-supported innovation management in service ecosystems?

This research question is answered by a system design that translates and transforms the requirements from RQ1 into tool functions. RQ2 is addressed through architectural design supported by theory-driven design and conceptual modelling.

Third, the system design resulting from research question two needs to be implemented in a concrete IT system instance. Furthermore, to demonstrate that the design artefact satisfies the requirements an evaluation of the artefact is necessary. This evaluation also allows learning from the design process and leads to the following, third research question:

RQ3 How can the system design be transformed into a concrete implementation and what can be learned from the implementation of the overall system regarding the design principles?

This research question is answered by a system implementation including the necessary data structures and algorithms. Moreover, an evaluation of the implemented IT system and reasoning about the development of the application will be the outcome of this part of the research. RQ3 is addressed through system development and evaluation including experiments and field tests.

1.3 Design Artefacts

As mentioned above, several artefacts are usually necessary to support the development of concrete IT applications. This section gives a short summary of the main design artefacts of the *TEXO Innovation Repository*. First, and most importantly, this work develops the Integrated System Design which contains the functional and architectural specification of a tool to support innovation management in service ecosystems. The Integrated System Design presents the central design principles necessary for an implementation of the overall system. This functional specification is complemented by the Idea Ontology, a (data) model to represent and exchange data which presents the second central design artefact. Finally, a concrete implementation of the system design and the Idea Ontology in a prototype application presents the third artefact (i.e., an instantiation). All experiences and extensions made during the implementation and evaluation of the prototype application are referred back to the Integrated System Design to document what has been learned during the system implementation of the design principles. This allows the Integrated System Design to stand as a central contribution to the knowledge base independently of the specific implementation followed in this work.

In addition to service and service ecosystems specific requirements that form the problem domain, this research is guided by the central realisation that productivity gain is no longer the single most important evaluation criterion of information system performance (Avital/Te'eni, 2009). Rather, a system's ability to increase creativity, reveal opportunities, and serendipitous discoveries is becoming more and more important. This type of system functions support *generativity* and are opposed to functions supporting *operational efficiency* (Avital/Te'eni, 2009).

The task of supporting innovation in service ecosystems requires a blend of both, operational efficiency (i.e., pushing ideas forward in the development process) and generative features (i.e., coming up with new service ideas). For information system design the "main concern here is fine-tuning the blend of operational efficiency and generative capacity for the particular task characteristics" (Avital/Te'eni, 2009, 352). Based on the environment requirements and the *theory of generative capacity* a unified framework for tool-supported innovation management in service ecosystems will be developed. This work argues that a tool to support innovation in an environment such as service ecosystems bringing together many different actors and organisations needs to be an open platform supporting generativity at its heart. Such a platform needs to be able to integrate different special-purpose tools ranging from visualisations for idea exploration to specialised rating tools for evaluation.

Based on specific requirements for the development of electronic services in the special setting of a service ecosystem this research uses a theory-driven approach to design, build, and evaluate a prototype IT system for innovation support in service ecosystems. Figure 1.1 summarises the main design artefacts developed in this research. The elements follow a layered model in which the upper elements build on lower ones. The Integrated System Design developed in Chapter 5 is the overarching set of architectural design elements that ties all aspects of the research together. The Idea Ontology developed in Chapter 6 provides the ontological foundation on which all other aspects of the prototype later build. The ontological foundation serves as the core data structure used to address the integration problem resulting from the Integrated System Design. Chapter 7 then develops a prototype that implements the different aspects of the Integrated System Design. The implementation is presented as four components. Each component extends the previous one, i.e., builds on it, and thus, step by step, develops a complete system. The first component (Section 7.1) serves as a base-line environment that allows basic operations like adding new ideas, writing comments, browsing, and searching existing ideas. The second component (Section 7.2) provides a technical foundation to address service ecosystems requirements and implement the Integrated System Design. Component three (Section 7.3) and four (Section 7.4) then provide exemplary implementation of one *op-*

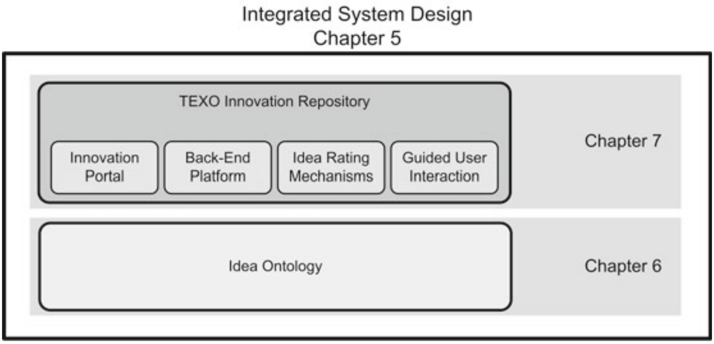

Figure 1.1: *Summary of artefacts developed in this research.*

erational efficiency feature and one *generative feature*. Each of the four components will address unintended side effects and experiences of the development process of the previous component, and thus gradually improve the concept of a tool-supported innovation environment for service ecosystems.

1.4 Structure

Following the design motivation of this work, the research is organised following the elements proposed by Walls/Widmeyer/El Sawy (1992) for design oriented work. First, the conceptual foundations of new service development, service ecosystems, and open innovation are developed followed by a specification of the requirements of the IT artefact to be developed. Then follows a deduction of an architecture for the artefact, the implementation of the artefact, an evaluation of the artefact, and a discussion of the results.

Chapter 2 first introduces the design science research method as discussed in the literature and extends the concept of theory-driven design. The chapter then describes the research design of this work.

Chapter 3 introduces the major conceptual foundations that will be of most importance to this research. The chapter provides a general introduction to service terminology, differences between electronic and non-electronic services, the development of new services, the service ecosystems domain, and open innovation as an approach to networked innovation and customer integration for the development of new services. The chapter identifies gaps in prior research and frames the theoretical contribution of this work. The chapter further specifies criteria for a solution and thus answers research question one.

Chapter 4 reviews the theory of generative capacity and related theoretical foundations. The review focuses on the more technical aspects and, in particular, the system design consideration of generative capacity. Based on the theory foundations laid out here, Chapter 5 will introduce an integrated system design for tool-supported innovation management in service ecosystems.

In order to seriously think about the world and effectively act in it, some sort of simplified map of reality, theory, or concept is necessary. Chapter 5 develops an integrated framework based on top-level directives to address many of the difficulties encountered in system development such as opposing methods, loose or unjustified selection of "random" functions, large and complex systems, and an integrated evaluation where it is hard to attribute benefits to any individual system feature.

Based on the integration challenge posed by the system design, Chapter 6 develops a solution for the integration problem based on Semantic Web using an ontology. The data model developed here serves as the fundamental data representation of this work. Chapter 5 and Chapter 6 together constitute the system design and answer research question two.

Chapter 7 presents the prototype development organised in four large sub-sections, one for each component of the system design. Each component section includes its own segments on related work, the detailed system design, the resulting implementation, and evaluation. This chapter addresses the third research question.

The research concludes in Chapter 8 with a summary and critical reflection of the achieved results. The chapter also proposes future research and implications for theory and practical implications. Figure 1.2 graphically summarises the structure of the work. In the figure, boxes denote the major chapters of the work while arrows indicate the logical flow and line of argument that link the individual chapters together. Chapter numbers are provided on the left and reference to the research questions addressed on the right.

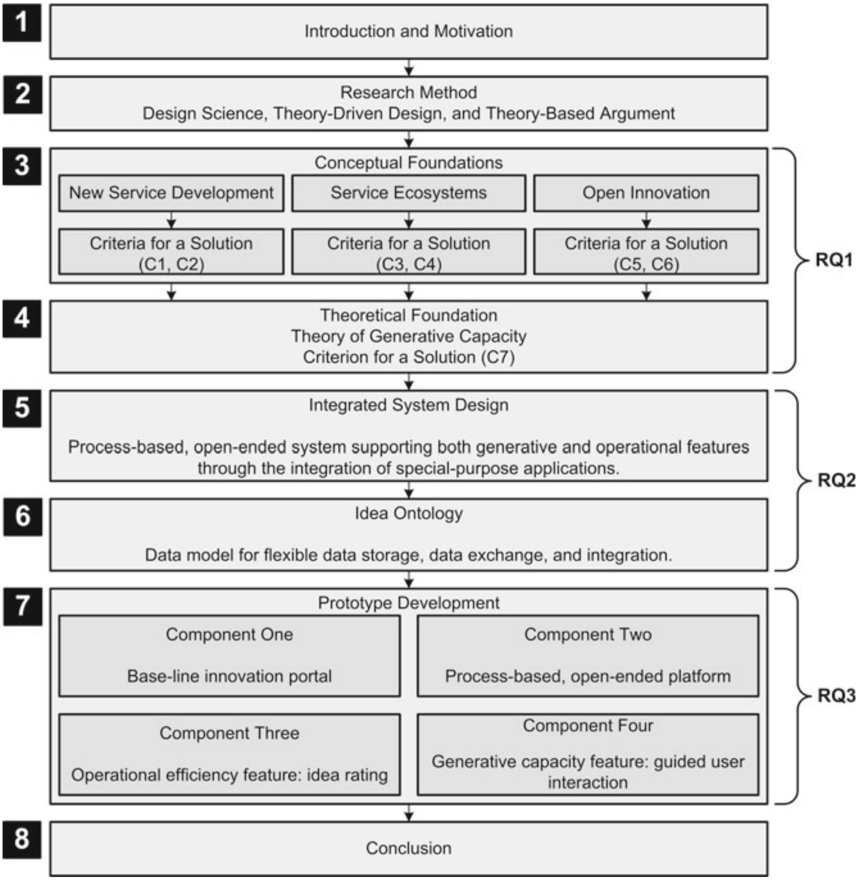

Figure 1.2: *Structure of this study.*

Chapter 2

Research Method

The discussion of methods is an important aspect of scientific research (Popper, 2002). The research process is the application of scientific methods to the complex task of discovering answers to questions (Nunamaker/Chen/Purdin, 1991). This chapter develops a research design for this research project (Chmielewicz, 1979). Based on the design goal and the design artefact of this research, this chapter first develops the necessary research method foundations and then derives a research design for this work based on these foundations.

Research in information systems is inherently multidisciplinary and employs many different methods (Palvia et al., 2004; Becker/Niehaves, 2007). In this research we used different methods ranging from empirical analysis through interviews and document analysis, statistics, to system design. The methods used in this work have been analysed in the corresponding literature regarding their strengths and weaknesses, condition for their application, and scope of potential results. Therefore, we want to refer to the corresponding literature; advisable for conducting a systematic literature review is Webster/Watson (2002) and Torraco (2005), for different forms of questionnaires, observations, and document analysis Bryman (2008), Miles/Huberman (1994), and Yin (2003) can be consulted, for statistical analysis Backhaus et al. (2008) is a good source. The mayor method and philosophical framework of this research, however, follows the design science paradigm. In the following we will therefore concentrate on the design science method and review it in detail. In design science oriented IS research a theoretical foundation of design processes and design artefacts is increasingly demanded (Gregor/Jones, 2007; Weber, 1987). Particular focus of this research is on the relationship between design research and theory. The review of design science will therefore focus on how theory can inform the design process and resulting artefacts, and whether or not design science can or should be used to develop or refine theories. Additional methods, for example, ontology engineering will be described in the respective sections.

The remainder of the chapter is organised as follows. This chapter first presents necessary philosophical foundations and assumption (Section 2.1). The chapter then reviews the design science research paradigm as discussed in the literature with particular emphasis on the use of theories in the design process (Section 2.2). Section 2.3 then describes the research design for the course of this research. Section 2.4 reviews advantages and limitations of the chosen research design. In the conclusion in Section 2.5 a summary

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table provides an overview of the research methods used to answer the respective research questions.

2.1 Philosophy of Science

Following Popper (1999), scientific work can be defined as the systematic and traceable quest for solutions to problems. Information systems research derives its problems from the research subject of information and communication technology (ICT) use in public or private contexts. The IS community has been discussing for years which research paradigms are suitable for this discipline (Österle et al., 2010). While Anglo-Saxon IS research is mainly grounded in behaviourism, the aim of continental IS research is rather the innovative design of information systems (Winter, 2008). Following a general convergence and globalisation of IS research the aim of IS research can be seen in creating knowledge about attributes and relationships of IT systems to allow the description, explanation, prediction, and design of ICT (Österle et al., 2010), and thus to combine rigorous research to establish credibility with the relevance of the design of innovative IT systems (van Aken, 2004; Rosemann/Vessey, 2008).

Objects of inquiry of IS research are information systems in economy and society, both for organisations and individuals. As socio-technical systems they comprise humans, ICT, and organisations (functions, business processes, structures, and management) as well as their relationships (Orlikowski, 1992). As a result, the knowledge base consists of published literature but also of information systems, software, organisational structures, tools, and methods in use and the experiences with these components. The scientific objective of design science-oriented IS research are design guidelines for the construction and operation of IT systems (Österle et al., 2010).

2.2 Design Science Research Paradigm

Simon's 1969 work *The Science of the Artificial* is largely considered the basis of design-oriented research (Winter, 2008). Together with seminal articles by Nunamaker/Chen/Purdin (1991), Walls/Widmeyer/El Sawy (1992), March/Smith (1995), and Hevner et al. (2004) it provides the methodological foundation of this work. The aim of this section is to give a short introduction to the science of the artificial and to gain a basic understanding of the term *design*. Artificial can be defined as "man-made," as opposed to natural; it is thus linked with the realm of engineering. Design is defined as directed towards a goal which is usually a solution to a problem. Design is concerned with how things ought to be; design aims at attaining goals (Simon, 1969). In science, natural things simply are and it is not meaningful to ask how they ought to be (Simon, 1969). Consequently, designs always have goals whereas natural laws do not; they simply are. Of the artefacts resulting from design, however, it can be asked both how they are and how they ought to be (Sunder, 2004). The introduction of goals, however, also brings with it the dichotomy between the normative and the descriptive (Simon, 1969). This results in a central aspect which has spawned many discussions: the consequent difficulty of disentangling prescription from description and the discussion whether artificial phenomena fall properly within the realm of science

(Simon, 1969). Furthermore, there is an intrinsic relationship between artificiality and complexity (Simon, 1969). Consequently, design science concerns complex systems that live in complex environments.

Design science is directed toward understanding and improving the search among potential components to construct an artefact that is intended to solve a problem. Design science has to do with systematic creation of knowledge about, and with, design (Baskerville, 2008). Design science is considered to be a research paradigm rather than a research methodology (Iivari, 2007; Baskerville, 2008). Consequently, the paradigm of design science needs to be combined with a suitable research methods, for example, system development or method engineering.

The Inner and Outer Environment Artefacts can be thought of as an interface between the inner environment and outer environment (Simon, 1969). The inner environment refers to the organisation of the artefact itself, the outer environment to the surrounding in which the artefact operates in and with which it interacts. The two approaches are different but still complementary which is why the behavioural science perspective can be contrasted with the design science perspective (March/Smith, 1995; Simon, 1969; Hevner et al., 2004). As artefacts are constructed to solve a given problem, they have to be judged regarding their problem-solving ability in the context of their environment. To evaluate a given solution regarding its problem-solving ability a utility function, decision variables, and constraints can be used (Simon, 1969). The extent of possible alternatives usually does not allow an optimisation but only a satisfactory solution. Simon (1969) introduced the term *satisficing* for this circumstance.

Design Research vs. Design Science Based on Winter (2008) a general distinction between *design science* and *design research* can be drawn. While design research aims at creating solutions to specific classes of relevant problems by using a rigorous development and evaluation process, design science reflects the design research process itself and aims at creating standards for its rigour. Design research aims at extending the boundaries of human and organisational capabilities by creating new and innovative artefacts (Hevner et al., 2004).

The following subsections introduce the basics of design research (Section 2.2.1), the relationship between design and theory (Section 2.2.2), and two methods for basing design on existing theories (theory-driven design, Section 2.2.3 and theory-based argumentation, Section 2.2.4). Particular emphasis is put on the evaluation of design science artefacts (Section 2.2.5).

2.2.1 Design Research

Design is a central aspect to IS research (Walls/Widmeyer/El Sawy, 1992). As noted above, design research creates and evaluates IT artefacts that are intended to solve identified organisational problems (Hevner et al., 2004). An important aspect of design research is learning through the act of building (Nunamaker/Chen/Purdin, 1991; Kuechler/Vaishnavi, 2008).

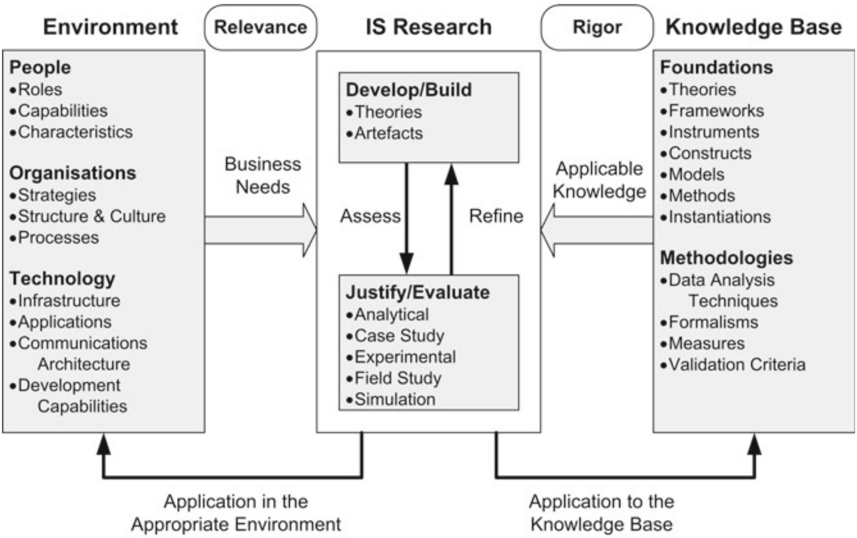

Figure 2.1: *Information Systems Research Framework (adapted from Hevner* et al.*, 2004).*

Hevner et al. (2004) propose a conceptual framework to perform design research in information systems. The aim of the framework is to provide clear guidelines for understanding, executing, and evaluating the research. Figure 2.1 shows this information systems research framework. It combines behavioural science and design science paradigms to achieve necessary rigour of design activities. It consists of three main concepts: environment, IS research, and knowledge base. The environment defines the problem space (Simon, 1969) for our research. This environment consists of people, organisations, and technology. Each of those three factors creates goals, tasks, problems, and opportunities that define different business needs. These are born of the people's perceptions within an organisation, because of their different roles, capabilities, and characteristics. Business needs provide the "problem," which has to be solved by the researcher. The research problem is solved using two complementary approaches: design science through *building* and *developing* and behavioural science through *justification* and *evaluation* (Hevner et al., 2004). These research methods are found to be inseparable in the field of information systems. While the goal of behavioural science is truth, the goal of design science is utility. The justify and evaluate activities are needed for artefact assessment and to identify weaknesses in the theories for their refinement. This cyclic process proves the importance of both approaches for the information systems. The knowledge base provides the foundation on which IS research builds. It consists of foundations and methodologies. The results and insights of previous research offer foundational theories, constructs, methods, models, and instantiations used in the develop/build phase of the research.

The following sections review design research in more detail. Section 2.2.1.1 offers a systematisation of design artefacts, Section 2.2.1.2 gives an overview of the design research process, and Section 2.2.1.3 offers guidelines for design research.

2.2.1.1 Artefacts of Design Research

March/Smith (1995) propose the following types of artefacts as outputs of design research. Their differentiation is well accepted in IS research (Winter, 2008) and other approaches of distinction result in the same or similar types of design artefacts (Hevner et al., 2004; Nunamaker/Chen/Purdin, 1991; Wand/Weber, 2002).

Constructs or concepts form the vocabulary for the description of the research problem and specification of its solution. They form a language which specifies the shared knowledge of a discipline. Such constructs can be either highly formalised as in semantic data modelling (having attributes, identifiers, constraints; Hull/King, 1987) or informal as in cooperative work (consensus, participation, satisfaction; Fjermestad/Hiltz, 2001).

Models are a set of propositions or statements representing relationships among constructs; they are a description of how things are. Using constructs as their language, models represent problems and solutions.

Methods are a sequence of steps (an algorithm) used to perform a task or to solve a problem. Methods are based on underlying constructs and models. Methods can be applied to transform one model to another in the course of solving a problem. Choosing a particular method for the solution of a task affects the developed constructs and models. Natural and design science differ in their conception of a method. Natural science uses but does not produce methods, while design science creates the methodological tools that natural scientists use.

Instantiations are the realisation of an artefact in its environment. They are a problem-specific aggregate of constructs, models, and methods. Only through the instantiation is it possible to evaluate the utility of a model or method (Walls/Widmeyer/El Sawy, 1992). The different characteristics of the IT artefact have been conceptualised in a taxonomy by Matook/Brown (2008).

It becomes apparent that the construction of design artefacts is informed by the existing knowledge base but also become a contribution to the knowledge base (Schermann, 2009).

2.2.1.2 Design Research Process

To guide the design research process and thus to ensure rigorous research different process steps have been proposed. However, no generally accepted process model has emerged (Winter, 2008). Table 2.1 gives an overview of a selection of design processes. The process proposed by Nunamaker/Chen/Purdin (1991) focuses on artefact development and thus is more detailed in the development phase as the other processes. Simon (1969) describes the process of design science as a generate/test cycle. That means, some design alternatives are generated, the performance of these is tested, and the requirements and constraints are specified that are again used for generating new alternatives. This cyclic refinement process is also encompassed in most of the other design research processes.

Generalised phases	*Hevner et al. 2004*	*March/Smith 1995*	*Nunamaker/Chen/ Purdin 1991*	*Peffers et al. 2006*	*Kuechler/Vaishnavi 2008*
Problem specification / requirements analysis	Problem identification		Construct a conceptual framework	Identify problem & motivation	Awareness of problem
				Define objectives of a solution	
Construction of artefact	Develop / build	Build	Develop a system architecture	Design & development	Suggestion
			Analyse and design the system		Development
			Build the (prototype) system		
Evaluation of artefact	Justify / evaluate	Evaluate	Observe and evaluate the system	Demonstration	Evaluation
		Theorise		Evaluation	
		Justify			
Contribution to knowledge base	Communication of results			Communication of results	Conclusion

Table 2.1: *Process models for design research.*

The cyclic refinement process and the detailed prototype development process proposed by Nunamaker/Chen/Purdin (1991) are of particular importance to this research. The cyclic refinement during the prototype development is explained in detail in Chapter 7.

2.2.1.3 Guidelines for Design Research

Design science is inherently a problem solving process (Hevner et al., 2004). To guide this problem solving process, Hevner et al. (2004) propose seven guidelines. These guidelines are derived from the fundamental principle of design research that knowledge and understanding of a problem domain and its solution are achieved through building and applying the designed artefact (Hevner et al., 2004). The guidelines are intended to help researchers, reviewers, editors, and readers to understand the requirements of effective design research. Without restraining their creativity of when and how to apply these guidelines, they show a way toward a good and complete design process. Table 2.2 summarises the seven guidelines. To ensure high relevance of IS research, additional guidelines can be found by Rosemann/Vessey (2008). It becomes obvious that the guidelines aim at a systematic research process where research results can be set in a clear relationship with, and evaluated by, the existing knowledge base. This research follows these guidelines for design research. The degree of achievement of this objective is reflected in the concluding chapter (Section 8.3).

2.2.2 Design Theories in Information Systems

In order for this research to embrace theory it is necessary to establish a basic understanding of the term and the relationship theories have with design research. Different authors have attached different meanings to the word “theory.” Gregor (2006) proposes a taxonomy of five different types of theory in use within the IS field: 1. theory for analysing,

Guideline	*Description*
Design as an Artefact	Design research must produce a viable artefact in the form of a construct, a model, a method, or an instantiation.
Problem Relevance	The objective of design research is to develop technology-based solutions to important and relevant business problems.
Design Evaluation	The utility, quality, and efficacy of a design artefact must be rigorously demonstrated via well-executed evaluation methods.
Research Contributions	Effective design research must provide clear and verifiable contributions in the areas of the design artefact, design foundations, and/or design methodologies.
Research Rigour	Design research relies upon the application of rigorous methods in both the construction and evaluation of the design artefact.
Design as a Search Process	The search for an effective artefact requires utilising available means to reach desired ends while satisfying laws in the problem environment.
Communication of Research	Design research must be presented effectively both to technology-oriented as well as management-oriented audiences.

Table 2.2: *Design science research guidelines (adapted from Hevner* et al.*, 2004).*

2. theory for explaining, 3. theory for predicting, 4. theory for explaining and predicting, and 5. theory for design and action. However, the attributes of the types in the taxonomy frequently blend (Gregor, 2006; Kuechler/Vaishnavi, 2008). In order to simplify matters of theory discussion in design research a two-category taxonomy is commonly used: kernel theories and design theories (Nunamaker/Chen/Purdin, 1991; Walls/Widmeyer/El Sawy, 1992; Markus/Majchrzak/Gasser, 2002; Goldkuhl, 2004; Kuechler/Vaishnavi, 2008). A similar distinction is expressed by Chmielewicz (1979).

Kernel theories often originate outside the IS discipline; they are theories from natural or social sciences. They intend to explain or predict phenomena of interest. Kernel theories describe cause-effect relationships and can be used to suggest novel techniques or approaches to IS design problems. Explanatory kernel theories are thus considered to be parts of design theories (Goldkuhl, 2004; Kuechler/Vaishnavi, 2008). Kernel theories also provide theoretical grounding for the artefact (Goldkuhl, 2004).

Design theories express practical knowledge to guide design activities (Goldkuhl, 2004). They relate to means-end relationships that abstract from a concrete artefact (Gregor/Jones, 2007). Design theories give explicit prescriptions for "how to do something" (Kuechler/Vaishnavi, 2008; Walls/Widmeyer/El Sawy, 1992; Markus/Majchrzak/Gasser, 2002; cf. also "theories for design and action" in Gregor, 2006).

A central realisation in design science is the duality of the word *design* as both a verb and a noun (Orlikowski/Iacono, 2001; Benbasat/Zmud, 2003). Consequently, design is both a product and a process (Walls/Widmeyer/El Sawy, 1992; Goldkuhl, 2004; Kuechler/Vaishnavi, 2008). As a product, a design is "a plan of something to be done or produced;" as a process, to design is "to so plan and proportion the parts of a machine or structure that all requirements will be satisfied" (Walls/Widmeyer/El Sawy, 1992, 42). A design theory must therefore have one aspect dealing with the product and one with the process of design. As the process yields the product the two aspects cannot be entirely independent. Walls/Widmeyer/El Sawy lists the following distinctive features of design theories which, based in theory, provide guidance to practitioners:

- Design theories must deal with goals as contingencies. Goals are intrinsic to a design theory.
- A design theory can never involve pure explanation or prediction. If it explains, it explains the properties or the design process of an artefact. If it predicts, it predicts achievement of the intended goals by the artefact.
- Design theories are prescriptive. They integrate explanatory, predictive, and normative aspects.
- Design theories are composite theories which encompass kernel theories from natural science, social science, and mathematics. The prescriptive plane provides common ground for integrating these different types of theories.
- While explanatory theories tell "what is," predictive theories tell "what will be," and normative theories tell "what should be," design theories tell "how to / because."
- Design theories show how explanatory, predictive, or normative theories are practically used.
- Design theories are theories of procedural rationality (Simon, 1969). They involve both the application of scientific theory and the use of the scientific method to test design theories.

The components of an information systems design theory proposed by Walls/Widmeyer/El Sawy (1992) are illustrated in Table 2.3. Referring to the product of design Walls/Widmeyer/El Sawy (1992) use the term *meta-requirements* rather than simply requirements because a design theory always refers to a class of goals rather than a specific goal. Analogue, they use *meta-design* to describe a class of artefacts to meet the meta-requirements because a design theory always addresses a class of artefacts and not a specific one (e.g., a payroll system for corporation XYZ). The distinction between kernel theories and design theories also relates to the distinction between prescription and explanation which is at the heart of many design philosophies (Simon, 1969). While a kernel theory provides an explanatory statement between a cause and an effect, a design theory gives a prescriptive statement that some means, or prescribed action, is intended to lead to a certain goal. As design theories build on kernel theories the relationships between the properties of an artefact and the level of goal attainment are determined by natural and social laws (Walls/Widmeyer/El Sawy, 1992). An instantiation of the components of the design theories used in this research will be presented in Chapter 5.

Cause-Effect Relationship Concepts are the building block of theoretical statements which are connected in theories to express a cause-effect relationship (Chmielewicz, 1979). They express empirical regularities. Cause-effect relationships can be expressed as *if* - *then* statements. For example, cognitive fit theory can be expressed as follows: *if* the problem representation matches the task requirements *then* the efficiency and effectiveness of the problem solving activity is improved (Vessey, 1991).

Means-End Relationship Theoretical cause-effect statements can be transformed into technical statements which use a means-end relationship instead of a cause-effect

Component	*Description*
	Design Product
Meta-requirements	Describes the class of goals to which the theory applies.
Meta-design	Describes a class of artefacts hypothesised to meet the meta-requirements.
Kernel theories	Theories from natural or social sciences governing design requirements.
Testable design product hypotheses	Used to test whether the meta-design satisfies the meta-requirements.
	Design Process
Design method	A description of procedure(s) for artefact construction.
Kernel theories	Theories from natural or social sciences governing design process itself.
Testable design process hypotheses	Used to verify whether the design method results in an artefact which is consistent with the meta-design.

Table 2.3: *Components of an information systems design theory (Walls/Widmeyer/El Sawy, 1992).*

statement (Chmielewicz, 1979). Effects correspond to aims, either in full or in part. The cause of the theoretical statement can be taken as a starting point for the means as long as it can be influenced by human action (Chmielewicz, 1979). If only some aspects of the effect are the desired aim, the remaining aspects of the effect are excluded as side effects.

Cause-effect and means-end statements are both generic statements with general validity rather than validity for only a single instance (e.g., a specific organisation). They are thus applicable to a whole class of instances. Walls/Widmeyer/El Sawy (1992) emphasise that a good theory (design and kernel) must be subject to empirical evaluation and potential dismissal (cf. Popper, 2002, first published in English 1959). In particular, the utility of an artefact can only be evaluated through instantiation and the subsequent evaluation of the artefact. Consequently, it is obvious that prototype construction is a major aspect of design research (Walls/Widmeyer/El Sawy, 1992).

Incorporating theories into the system design allows design research to reason on the effects of the resulting artefact prior to its realisation (Gehlert et al., 2009; Schermann et al., 2009; Schermann, 2009). This offers tremendous benefits during design and evaluation. During design it becomes possible to reason if the resulting artefact will be able to achieve the stated goal which can save implementation efforts. During evaluation it becomes possible to focus in particular on certain aspects which will be known to be the source of major difficulties (e.g., with user interaction) prior to the realisation of the artefact. This allows design researchers, for example, to add specific sub-routines to capture relevant data to allow a more detailed analysis of the actual results.

The view that kernel theories can and indeed should be used to inform design theories is well accepted (Kuechler/Vaishnavi, 2008). A central discussion in design science, however, evolves around the question whether design theories can or should be used to develop new or refine existing kernel theories (Kuechler/Vaishnavi, 2008). This view is supported by several scholars (Simon, 1969; Nunamaker/Chen/Purdin, 1991; Venable, 2006; Romme/

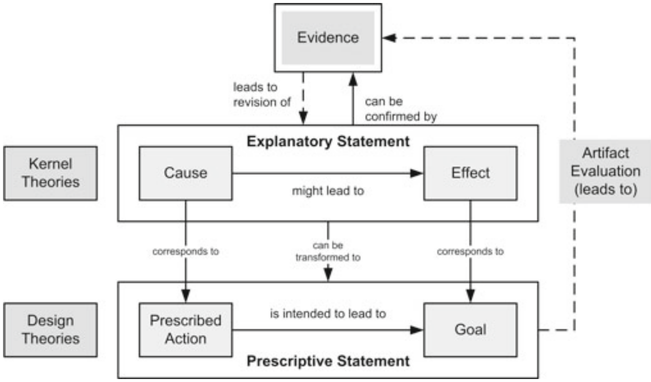

Figure 2.2: *Relationships between kernel theory and design theory, and the design process (adapted from Goldkuhl, 2004 and Kuechler/Vaishnavi, 2008).*

Endenburg, 2006; Kuechler/Vaishnavi, 2008; Schermann et al., 2009). We agree with this view that design research can be informed by (kernel) theories, but can also refine existing kernel theories. In the later part of this work we try to demonstrate how existing theories can be refined through the contribution of design research (cf. in particular Section 7.3).

The relationships between kernel and design theories and the feedback loop from artefact evaluation to confirmation and refinement of kernel theories discussed above are summarised in Figure 2.2. Instantiations of this figure with named attributes will be used in Sections 7.1, 7.2, 7.3, and 7.4 to illustrate in detail the theory used (cause-effect relationship) and the resulting design theory (means-end relationship) of the four components of the TEXO Innovation Repository that have been developed in this research.

2.2.3 Theory-Driven Design

Early efforts to design and deploy IT systems, in particular those to support collaboration, frequently failed in delivering the desired improvements and where more art than science (Fjermestad/Hiltz, 2001). For that purpose, Briggs (2006) proposes theory-driven design. It is an approach to base design choices on theory foundations in order to arrive at justifiable system designs. Moreover, he argues that using a theory-driven approach enables researchers to arrive at non-intuitive design choices that can lead to better results than those possible with more intuitive approaches. Examples of research following theory-driven design can be found by Leimeister et al. (2009) and Consolvo/McDonald/Landay (2009). While Briggs's approach is based on similar thoughts expressed by Walls/Widmeyer/El Sawy (1992) and others presented above, the approach is rather pragmatic and tries to offer actionable advice to design researchers (Briggs (2006) contains no reference to any of the design theory literature presented above).

To apply theory-driven design, Briggs (2006) proposes to follow four steps. The first step is to explicitly identify the phenomenon of interest. Exactly what outcome(s) does the designer seek to improve with the technology? The intended outcome is not always obvious and so explicating it is a required first step. In the area of collaboration research, for example, possible phenomena of interest could be productivity, creativity, or satisfaction. Once the phenomenon of interest is identified it has to be defined in order to make clear what the intended outcome is as words can have different connotations. Different connotations would, in turn, have different theoretical explanations. The English word *satisfaction*, for example, could be interpreted as either a *judgement* that a goal has been achieved or as an *emotional response* pertaining to goal attainment. The third step is to challenge one's choice if the defined phenomenon of interest is the most useful or important target for improvement (Briggs, 2006). There might possibly be other phenomena which are of greater interest and which might lead to better results. The guiding question in this step is Whose life might be improved? Whose work might be more effective? Once a truly convincing case has been established that demonstrates that a certain desired outcome is worthy of one's effort the fourth step is to seek to find a good theory on which to base the research on.

According to Briggs (2006) there are several limitations and challenges in applying the theory-driven design approach. One is the temptation of using "grand theories of everything" (Briggs, 2006, 579). These theories propose a plausible umbrella construct that results in a large selection of outcomes. For example, *group process* can be used to influence effectiveness, creativity, or satisfaction. However, some of these outcomes may be caused by different mechanisms than others. Some of these mechanisms may even be contradictory (e.g., a highly structured group process may lead to more effectiveness but reduce satisfaction with its users). Thus, these theories are not well suited to guide theory-driven design. Another temptation is to use "grand theories of nothing" (Briggs, 2006, 579). These theories posit general antecedents that have been generalised to such an extent that they can hardly be wrong but lack any concise statements useful for design. For example, the theory that *environment influences outcomes*. As a plausibility check, Briggs (2006) proposes to use the sentence construct "The more Z you have, the more Y will result" as *absurdity test*. Testing the above theory would result in a statement like *The more environment a group has, the more outcomes they will attain* which obviously provides no further insights into how to design a system.

2.2.4 Theory-Based Argument

Theory-driven design offers a way how a clearly defined system feature can be designed based on a single kernel theory. However, problems arise when multiple kernel theories are necessary to realise more complex design goals. The method of theory-based arguments tries to address this shortcoming. While theory-driven design is suitable for single theory designs, the approach of theory-based argumentation proposed by Gehlert et al. (2009) and Schermann et al. (2009) tries to provide a method for designing complex systems that cannot be realised using a single kernel theory but may require the use of multiple kernel theories. A key issue lacking in the design theory approaches presented in Section 2.2.2 and theory-driven design suggested by Briggs (2006) is the inability to use the outcome of one design phase resulting from the use of one theory as the input for the next design phase using a different theory.

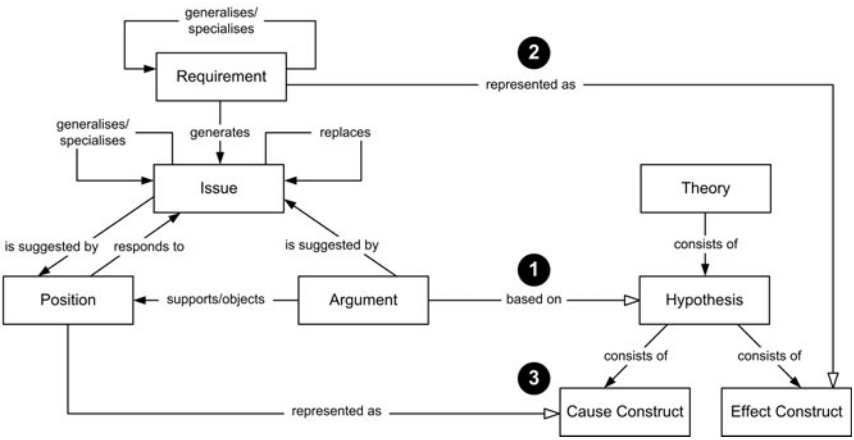

Figure 2.3: *Theory-based argumentation through an integration of theories into IBIS (adapted from Schermann* et al.*, 2009).*

Based on the notion of design rationales, theory-based argumentation aims at documenting design decisions during the design process in a transparent way (Gehlert et al., 2009). Design rationales (DR) serve as a documentation of the design process and enable the design researcher to trace design decisions (Moran/Carroll, 1996; Louridas/Loucopoulos, 2000; Regli et al., 2000). Design rationale aims at capturing the *why* behind the *how* in design and provides the logical reasons given to justify a designed artefact. Furthermore, it provides documentation not only of the reasons for the design of an artefact but importantly also of the stages or steps of the design process (Moran/Carroll, 1996). Thus, it addresses the single-step shortcoming of theory-driven design presented above. Through the process-oriented nature of the approach decisions made during the design process can be traced. The reasoning loop of design rationale is based on hypotheses ("any suggestion, proposal or idea about the resolution of a problem in the design process" Louridas/ Loucopoulos, 2000, 217) which are then (or, more precisely, need to be) evaluated to arrive at justifications. Gehlert et al. (2009) combine this approach with theory-driven design where design hypotheses can be replaced through hypotheses representing cause-effect relationships of established theories. This allows reasoning about the artefact prior to its realisation and the evaluation, simply based on theories, rather than the experience of the design researcher.

A basic argumentation structure used for different DR approaches is the *Issue Based Information Systems* (IBIS) approach (Conklin/Begeman, 1988; see Louridas/Loucopoulos, 2000 for an extensive review). The IBIS consists of the following three constructs:

Issues represent anything that needs to be discussed, deliberated, and put into argumentation during a design project (i.e., the design problem).

Positions are ways of resolving issues.

Arguments are statements supporting or objecting to positions.

Figure 2.3 shows the integration of theories into the IBIS approach. The integration builds on three assumptions (❶, ❷, and ❸ in Figure 2.3). Arguments themselves do not explain why supporting or objecting a position resolves an issue. If, however, arguments are grounded in theoretical knowledge, it is possible to trace not only which arguments lead to the decisions but also why these arguments contribute to the requirements of a design principle (❶). Furthermore, whenever an argument is represented by a hypothesis it becomes necessary to map the hypothesis' effect construct to the requirement (❷) and the hypothesis' cause construct to the respective position (❸). The links ❷ and ❸ represent how the position and the requirement are interpreted in the light of the theory used in this design phase (Schermann et al., 2009). Through the representation of issues through positions and arguments based on theories, it also becomes possible to reason about opposing effects that theories might have and document design decisions in an inter-subjective way. This research builds on an extended version of the methodological approach for integrating theories into the design research process through theory-based arguments. Section 2.3 presents the modified methodological approach used in this research and 5.4.2 presents the Integrated System Design and details the specific theories and argumentation for this research.

2.2.5 Evaluation of Design Science Artefacts

The central point of difference between behavioural research and design science is the claim of utility of the resulting artefacts and the introduction of goals into the design process. A central aspect of design science is to substantiate, to ground, the claims of utility and the solution of problems which were expressed as design goals. This introduces the need for artefact evaluation. Grounding means justifying knowledge by claiming its validities with usefulness being the main validity claim of design theories (Goldkuhl, 2004). As has been noted above, only through the instantiation is it possible to evaluate the utility of an artefact (Walls/Widmeyer/El Sawy, 1992). It is possible, however, to evaluate other aspects of an artefact without instantiation (e.g., internal consistency) but not its utility.

The concept of evaluation has been defined by Scriven (1991, 139), as the "process of determining the merit, worth, or value of something, or the product of that process." Different approaches are available to differentiate evaluation methods, e.g., according to the purpose of evaluation (summative and formative evaluation, Scriven, 1997) or empirical and non-empirical (Siau/Rossi, 2010). Hevner et al. (2004) proposes the following approaches to evaluate an artefact: analytical, case studies, controlled experiments, field studies, and simulations. Table 2.4 provides a summary of evaluation methods used in IS research. Furthermore, prototypical implementation of concepts, models, and processes can serve as a proof-of-concept (Nunamaker/Chen/Purdin, 1991). Artefact instantiation in general and a prototypical implementation in particular demonstrate the feasibility of the designed artefact. Thus, a prototype implementation provides proof by construction (Nunamaker/Chen/Purdin, 1991; Hevner et al., 2004). Different evaluation methods have been used throughout this research to evaluate the design artefacts. The exact course of the evaluation will be presented in conjunction with the respective design artefact.

Evaluation of Theory-Driven Design Artefacts The evaluation of theory-driven design artefacts has not been systematically discussed in literature. Briggs (2006), in

Evaluation Type	*Method and Description*
Observational	Case Study: study artefact in depth in business environment. Field Study: monitor use of artefact in multiple projects.
Analytical	Static Analysis: examine structure of artefact for static qualities (e.g., complexity). Architecture Analysis: study fit of artefact into technical IS architecture. Optimisation: demonstrate inherent optimal properties of artefact or provide optimality bounds on artefact behaviour. Dynamic Analysis: study artefact in use for dynamic qualities (e.g., performance).
Experimental	Controlled Experiment: study artefact in controlled environment for qualities (e.g., usability). Simulation: execute artefact with artificial data.
Testing	Functional (Black Box) Testing: execute artefact interfaces to discover failures and identify defects. Structural (White Box) Testing: perform coverage testing of some metric (e.g., execution paths) in the artefact implementation.
Descriptive	Informed Argument: use information from the knowledge base (e.g., relevant research) to build a convincing argument for the artefact's utility. Scenarios: construct detailed scenarios around the artefact to demonstrate its utility.

Table 2.4: *Design evaluation methods (Hevner* et al.*, 2004).*

particular, does not offer any suggestions on how to artefacts following his approach of theory-driven design can or should be evaluated. On a general level, three potential outcomes of artefact evaluation can be identified (Weiss, 1972). First, a successful artefact starts a causal process which will then lead to the desired effect. In case of a theory failure, the artefact starts the causal process but this does not lead to the desired effect due to a shortcoming of the theory. Finally, program failure occurs when the artefact does not start the causal process which would have lead to the desired effect (Figure 2.4).

Against this background, two types of evaluation approaches can be distinguished: output-oriented and outcome-oriented evaluation (Kromrey, 2001; Love, 2004). Output-oriented evaluation focuses on the specific result of the use of an artefact (Kromrey, 2001). In the case of tool support for innovation management in service ecosystem the evaluation would consequently focus on the creation and collection of ideas, and their management across the phases of the innovation process. The guiding evaluation question would be if the artefact allows its users to start the causal process identified by the designer. Otherwise, program failure occurs. Outcome-oriented evaluation, on the other hand, focuses on the effects achieved by the application (Kromrey, 2001; Weiss, 1972). In the case of this research, this would mean actual new services developed for service ecosystem and their market success. The guiding evaluation question would be if the artefact allows its users to achieve the desired outcomes (in this case: to support innovation). Outcome-oriented evaluation in meaningful terms is very difficult and only possible within narrow bounds (Hamilton/Chervany, 1981; Weiss, 1972; Hirschheim/Smithson, 1999). Outcome-oriented evaluation would, for example, demand that the artefact be introduced and implemented

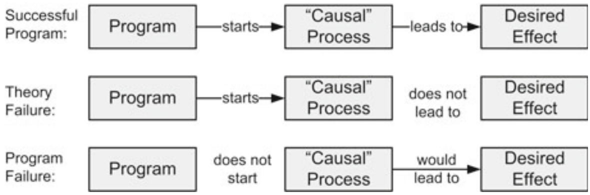

Figure 2.4: *Successful artefact evaluation (adapted from Weiss, 1972).*

in significant amount of organisations to allow empirical analysis (Frank, 1998). The application domain, however, is difficult to influence by the design researcher (Frank, 1998). Work by Schwabe (2000) and Leimeister (2005), for example, demonstrate that very specific conditions have to be met for piloting. Krcmar/Böhmann (2004) emphasise that piloting requires in most cases considerable resources. Weiss (1972) argues that in case sufficiently corroborated theoretical statements provide the basis of artefact design, outcome-oriented evaluation can, initially, be dispensed with. Instead, the exact starting of the causal process should be the focus of the evaluation process.

Schermann (2009) identifies three aspects, or entry points, relevant for the evaluation of theory-driven design decisions and the resulting artefact: the knowledge base, the function of the artefact, and the resulting effect. This relationship is shown in Figure 2.5.

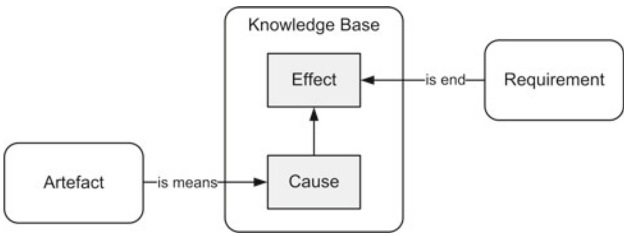

Figure 2.5: *Means-end relationship of design decisions (adapted from Schermann, 2009).*

The knowledge base provides theoretical statements as cause-effect relationships which are deemed relevant in the context of the artefact application. In case of well established theories it is assumed that the theory will hold and a theory failure can be ruled out. The second part of the design argument consists of the statement that the artefact actually provides functions ("is means") which are able to influence the cause-effect relationship. Based on theoretical statements it can then be assumed that the predicted effect will result. The third part of the design argument consists of the statement that the resulting effect satisfies the requirements to the desired degree ("is end"). Focus of the evaluation of theory-driven design should consequently be on

1. the mapping between artefact function and theory cause: that the artefact is able to start the causal process, and
2. the mapping between requirements and theory effect: that the predicted effect satisfies the requirements.

Contrary to common evaluation approaches the focus should not lie on an evaluation of the effects achieved by an artefact - this is given by existing theory - but rather on the ability of the artefact to start the causal process and the appropriateness of the predicted effect in light of the desired goals.

Figure 2.6 displays the relationship between the effects of a theory and the ends of the artefact as two overlapping circles. In the range of overlap are those effects that have been achieved and which resulted in desired ends. However, the overlap between effects and aims, particular in realistic settings, is unlikely to be perfect. Rather, it has to be expected that certain ends remain unmatched and that additional (undesired) side effects are caused as a byproduct.

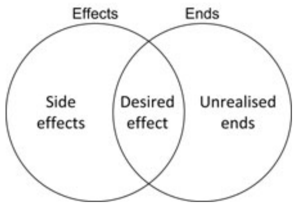

Figure 2.6: *Difference between effects and ends (based on Chmielewicz, 1979).*

2.3 Research Design

The discussion of methods is a central aspect of design-oriented research. This section describes the research design used by this work. The research design is guided by a combined approach of Weiss (1972), Chmielewicz (1979), Goldkuhl (2004) and Kuechler/ Vaishnavi (2008), and Gehlert et al. (2009) and Schermann et al. (2009).

Research Process Based on the process of theory-driven design and theory-based argumentation the research process for this work has been derived. This research process details in particular the design phase of the overall design research process (cf. Section 2.2.1.2). First, based on a given design goal which has been decomposed into a set of requirements a suitable kernel theory has to be identified. This results in the mapping between requirements and theory effect (cf. Chmielewicz, 1979; Weiss, 1972; Schermann, 2009; see Section 2.2.5). Next, the cause-effect relationship of the kernel theory is transformed into a matching means-end relationship resulting in a design theory (cf. Walls/ Widmeyer/El Sawy, 1992, Goldkuhl, 2004, and Kuechler/Vaishnavi, 2008; see Section 2.2.2). This involves the mapping of artefact function on the theory cause (cf. Schermann et al., 2009). Through the use of system implementation and prototyping the resulting system design is then implemented as a program. Based on Chmielewicz (1979) three types of outcomes will result from the application of the program: intended effects, unrealised ends, and side effects (cf. Chmielewicz, 1979; see Figure 2.6). Intended effects serve towards achieving the overall design goal (IT support for innovation management in service ecosystems) and the satisfaction of the requirements. Unrealised ends mean that certain goals of the artefact design have not been achieved and unsatisfied requirements remain to be implemented. Unintended side effects imply that the system design also caused certain effects which are not desired. These unintended side effects force the designer to make certain tradeoffs in the design to alleviate the negative effects. Figure 2.7 illustrates the complete research process.

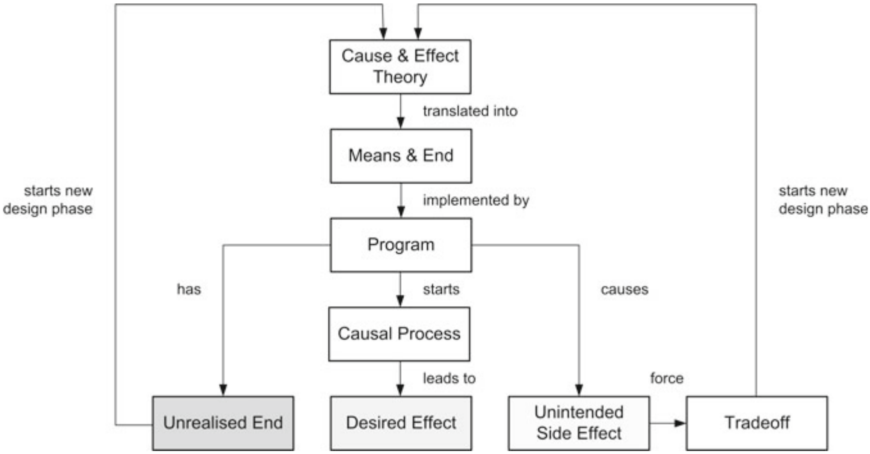

Figure 2.7: *Theory-driven argumentation of this research.*

Unintended Side Effects Two things are important to note regarding unintended side effects. First, "unintended" does not mean "unknown in advance." It simply means that effects emerged that are not desired, but this may well be anticipated in advance. For example, the introduction of optional properties in a modelling grammar will increase its complexity. This increase in complexity is unintended but well known in advance. Second, knowing in advance that certain unintended side effects occur (or are likely to occur) does not prevent one from 1. demonstrating that the effects actually did occur through an evaluation and 2. to learn from it (in the sense of iterative development). This approach has the following advantage. As certain undesirable side effects are already expected (deduced from theory) the evaluation and subsequent development can focus even more on this particular effect.

A new design cycle has to be started in two different cases. Either, certain ends remain unachieved (e.g., due to the complexity of the design goal or through a deficiency in the theory) or the artefact causes unacceptable side effects that force tradeoffs to be made. If all requirements are satisfied and resulting side effects have been addressed through tradeoffs or are only of acceptable extent, it seems reasonable to stop the design process (cf. concept of *satisficing* by Simon, 1969). The term *design phase* will be used to refer to each design cycle. It is important to stress the fact that these design phases, or "iterations," are not emergent. Due to the theory-based argumentation it becomes possible to reason about an artefact prior to its instantiation (Weber, 1987) and thus to reason about possible next steps that need to be taken in order to satisfy the remaining requirements and alleviate unintended side effects. This way it is possible to design a complete system consisting of multiple design phases involving multiple kernel theories. The process steps summarised in Figure 2.7 are central to the system design developed in this research. Each design phase of this research presented in Chapter 5 is guided by this process. The presentation will also follow this process resulting in the respective sub-sections

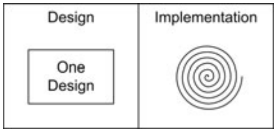

Figure 2.8: *Theory-driven design and iterative implementation.*

for 1. cause-effect relationship, 2. means-end relationship, 3. program, 4. unintended side effects, and 5. tradeoffs.

Theory-Driven Design and Implementation Following the design of the overall system through the design process just described, the system is implemented using common methods of system implementation and software engineering (Nunamaker/Chen/Purdin, 1991; Sommerville, 2007). Here, prototyping is used as a proof-of-concept to demonstrate feasibility of the proposed system design and to learn about concepts and frameworks resulting from the system design (Nunamaker/Chen/Purdin, 1991). The system implementation will be organised in smaller, more manageable parts. These parts will be called *components*. Each component will have its own analysis (i.e., state of the art review), theory base (i.e., kernel theory), detailed system design, and evaluation section. The individual component evaluations will focus on a very specific aspect of the component as predicted by the respective theory. Thus, it will be possible to judge if the component design was able to start the causal process that will lead to the aspired effect as predicted by the respective theory. However, the program might also cause unintended side effects which in turn force the designer to make tradeoffs in the system design decisions and to start a new design cycle (see Figure 2.7).

This component-based approach avoids problems that are common to larger piloting settings where complete systems are deployed and evaluated because it is difficult to attribute the observed effects to individual tool features. In the component-based approach it is easier to control the environment and, ceteris paribus, to isolate the treatment effect. Thus, in a piloting setting it is more difficult to justify a system design by attributing desired outcomes to these design decisions due to the increased complexity of the system.

Through the use of theories, it becomes possible to reason about the outcome before instantiation. This allows decoupling the design process from the implementation process in which design phases do not necessarily have to correlate with implementation phases. For example, it is possible to design a system using four design phases but then implement it in a single step or vice versa. For risk reduction (e.g., it might be the case that one design aspect cannot be implemented as planned due to technical problems) it seems reasonable to perform the implementation in cycles (cf. the Rational Unified Process for iterative software development, Kruchten, 2000). These cycles, however, need not necessarily correspond with the design phases and, above all, are not an emergent result of an evaluation of the previous implementation step. Figure 2.8 visualises the relationship between a single, overall system design resulting from theory-based argumentation and iterative implementation divided into several components.

2.4 Critical Reflection of Research Design

This section provides a critical review of the advantages and limitations of our research method, first, of the theory-driven design in general, and second, of the specific research design followed in this work.

Incorporating theories into system design is generally considered desirable and is advocated by many design-oriented researches (cf. Nunamaker/Chen/Purdin, 1991; Walls/Widmeyer/El Sawy, 1992; Goldkuhl, 2004; Briggs, 2006; Kuechler/Vaishnavi, 2008). Using a design theory based on theoretical underpinnings can guide the design process to result in artefacts which are both effective and feasible. Additional advantages of theory-based design are the ability to reason on the effects of the resulting artefact prior to its realisation, making design decisions more inter-subjectively traceable, and avoiding loose or unjustified selection of "random" features. Eventually, theory-based design may also lead to highly effective, non-intuitive design solutions.

Theory-driven design has, however, several limitations. First, it is a rather new method and, until now, not many applications have been reported. This can make communication of research results in the scientific community difficult due to the usage of a non-standard method. The theory-driven design approach propagated by Briggs (2006) suffers from a narrow definition of the term *theory*. In spite of building on similar thoughts as, for example, Walls/Widmeyer/El Sawy (1992), the theory-driven design proposed by Briggs (2006) is not grounded in the more general approaches linking design with theory. Despite this limitation, or possibly because of it, the approach taken by Briggs is rather pragmatic and offers actionable advice to design researchers. Until now, literature does not provide a systematic discussion of the evaluation of theory-driven design artefacts. Most notably, Briggs (2006), does not offer any suggestions on how to evaluate theory-driven design artefacts. A general problem in the evaluation of theory-driven design artefacts is the definition of the evaluation objective. According to Weiss (1972) the evaluation should focus on the relationship "program starts causal process." But how can "starting of a causal process" be evaluated? Starting a causal process is usually not observable. This may lead researchers to again evaluate against the desired effect which is predicted by the theory and is an observable result (cf. Leimeister et al., 2009). Furthermore, fine-grained theories are necessary to apply them in theory-driven design. However, theories of the required granularity are rarely available. Additional limitations arise if no suitable theory to guide the designer can be found. In this case, the design researcher has to develop own theories, or at least preliminary hypotheses, to guide the design process.

The specific research design proposed for this research has two main advantages. First, it offers clearly defined process steps making the design rigorous. Second, the research design systematically takes into account various outcomes of system evaluation and potential side effects. It thus provides a method for reasoning about complex system designs involving multiple theories.

Limitations of the approach are that it tends to makes the system design more complex due to the incorporation of additional aspects (i.e., theories). Furthermore, the very explicit statement of design decisions makes the system design more vulnerable to objections. Despite generally being considered a positive aspect, it makes it harder for the system designer to hide behind personal experience and intuition. Finally, the research design process proposed for this research implicitly assumes that there are no unknown side effects; that the (design) theories are completely independent and do not influence each other in unknown ways. This could lead to ignorant designs and overreliance on theory at the expense of intuition and common sense.

On the most general level, theory-driven design and the research design proposed for this research do not automatically solve the central design goal: utility. Answering the design questions “Is it useful?” and “Might something else have a higher impact?” still remains. However, even if the design process does not lead to better outcomes, the design approach at least documents design decisions and thus makes the design process comprehensible and traceable.

2.5 Summary

This section introduced relevant aspects of the research method used in this research. Section 2.1 quickly reviewed some basic philosophical aspects and assumptions. Section 2.2 then developed in detail the design science research paradigm including design artefacts, process models, and guidelines. Particular focus has been put on the integration of theories into the design process (Sections 2.2.2, 2.2.3, 2.2.4). Section 2.2.5 elaborated how design artefacts in general and those designed through theory-based approaches in particular can be evaluated. Section 2.3 finally presented the research design of this work. Section 2.4 discussed advantages and potential limitations of the research design. In summary, combining the theory-based design rationale process with additional concepts about possible artefact evaluation results provides a powerful method for artefact design and implementation. As the introduction already mentioned we used different research methods through the course of this research. Table 2.5 summarises the research methods used in this work to answer the research questions and produce the research outcomes.

Chapter 5 and Chapter 6 will present the overall system design based on the research process described above. Chapter 7 will then present the implementation of the prototype system divided into four components. But first, the next two chapters will introduce the necessary conceptual and theoretical foundations for this research and decompose the overall design goal to provide IT support for innovation management in service ecosystem into a set of seven criteria for a proposed solution.

Research Question	*Research Method*	*Outcome*
RQ1	• Literature review	Conceptual foundations Research gap and contribution Criteria for a solution
RQ2	• Empirical analysis / document analysis • Ontology engineering • Interviews (for competency questions) • Conceptual modelling • Theory-driven design	Actor model System design Idea Ontology
RQ3	• Prototyping / system development • Scenario evaluation • Informed argument • Laboratory and field experiment • Questionnaire • Log-file analysis	Implementation Evaluation

Table 2.5: *Research questions and the methods used to answer them.*

Chapter 3

Conceptual Foundations

Service science and innovation research lies at the intersection of different research areas (e.g., Chesbrough/Spohrer, 2006; Spohrer et al., 2007) including computer science, management science, organisation research, and even cognitive psychology are touched upon. *Service science* can be defined as an "interdisciplinary field of inquiry that focuses on fundamental science, models, theories, and applications to drive service innovation, competition, and well-being through co-creation of value" (Ostrom et al., 2010, 5). As is common in the IS field (Becker/Niehaves, 2007) and service science, this research is inherently interdisciplinary and in the absence of a grand unifying theory draws on several different research areas for its various parts. This chapter introduces the major conceptual foundations that are most important to this research. The chapter first provides a general introduction to service terminology and then elaborates the differences between electronic and non-electronic services. The chapter then reviews literature on the development of new services, the service ecosystems domain, and open innovation as an approach to networked innovation and customer integration for the development of new services. The development of new services is an area of service management research related to service design and is commonly referred to as *new service development* (NSD) (Menor/Tatikonda/Sampson, 2002).

It is proposed that in order to provide tool support for innovation management in service ecosystems it is necessary to develop these conceptual foundations in order to derive criteria that the resulting tool has to address. For that purpose, we propose six criteria for a solution throughout this chapter. Whilst the criteria address specific requirements in service ecosystems, they also address more general requirements of supporting the design of electronic services as opposed to non-electronic services, and build on general foundations for new service development. These criteria serve to answer research question one from Section 1.2.

The research area of new service development provides the central and core foundation for this research as it offers concepts and methods for the development of new services in a holistic way. The review of NSD related research is exhaustive and systematic (i.e., complete in an intersubjectively comprehensible manner). This is necessary to establish that currently no approaches for new service development exist that are suited to the development of electronic services as they are found in service ecosystems (i.e., to establish a clear research gap). The review of service ecosystem and open innovation are exhaustive

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and serve as a conceptual basis for this research. Furthermore, the review of service ecosystem and open innovation literature frames the theoretical contribution of this work by establishing in which ways this research contributes to existing knowledge.

The remainder of this chapter is organised as follows. Section 3.1 introduces different service terminologies and offers a definition of *e-service* that will be used in the remainder of this work. Then, Section 3.2 develops five areas of key differences between electronic and non-electronic services. Section 3.3 provides a systematic review of new service development literature. Section 3.4 and 3.5 review relevant literature on service ecosystems and open innovation as an approach to networked innovation and customer integration for the development of new services. Throughout the three sections on new service development, service ecosystems, and open innovation we propose six criteria for tool-supported innovation management in service ecosystems, two in each section. The criteria are summarised in Section 3.6 which concludes the chapter.

3.1 Service Terminology

This research about service ecosystems and online provisioning of services is set in an interdisciplinary research context with contributions from various research areas. Different interpretations of the terms service, electronic service, e-service, and Web service can be found in business science, information science, information systems research, and computer science (Baida/Gordijn/Omelayenko, 2004). A clear understanding of the various definitions of these terms is essential to facilitate reasoning about services. The following paragraphs provide an overview of the existing usage of the term and give a working definition that will be used throughout the remainder of this work.

Service The term service usually refers to the business science definition of service. Many different approaches exist to define services and no universally accepted definition has emerged as of yet. Table 3.1 summarises common service definitions.

E-Service For the term electronic service, or e-service, the business science definition of the term is commonly implied. Rust/Kannan (2003, 38) define e-service very broadly as “the provision of service over electronic networks.” Electronic networks include, but are not limited to, the Internet. Other electronic environments such as mobile networks, ATMs, and self-service kiosks are also included in this definition.

In business science literature, this usually refers to an Internet-based version of traditional services (Baida/Gordijn/Omelayenko, 2004). This includes both, services that only use the Internet as an user-interface but where actual service fulfilment might include non-electronic channels (e.g., online shopping), as well as services that are entirely delivered electronically (e.g., music download). The notion of e-services is not limited to the business-to-consumer domain but also encompasses the domains of business-to-business, government-to-public, and intraorganisational entities (Rust/Kannan, 2003). The terms electronic service and e-service are used interchangeably and refer to the same understanding of the subject matter. Williams/Chatterjee/Rossi (2008) uses the term “digital service” instead of e-service. For a distinction between e-services and IT-services Böhmann (2004) can be consulted.

"[A service is] an act or performance offered by one party to another" (Lovelock/ Wright, 1999, 5)
"A service is a change in the condition of a person, or a good belonging to some economic entity, brought about as a result of some other economic entity, with the approval of the first person or economic entity" (Hill, 1977, 318)
"A service is any act or performance one party can offer to another that is essentially intangible and does not result in the ownership of anything" (Kotler/Keller, 2009, 386)
"[We] define services as the application of specialized competences (knowledge and skills) through deeds, processes, and performances for the benefit of another entity or the entity itself" (Vargo/Lusch, 2004, 2)
"A service is a time-perishable, intangible experience performed for a customer acting in the role of a coproducer" (Fitzsimmons/Fitzsimmons, 2006, 4)

Table 3.1: *Overview of services definitions.*

Web Service Web service is a term used in computer science and is usually not found in business science. When used in business science, it either refers to the computer science definition or it simply refers to services delivered over the Web in the meaning of e-service (Baida/Gordijn/Omelayenko, 2004, 3). In a computer science context, Web service is defined using either a technology-free approach or a technology-specific approach. In the technology-free interpretation the W3C defines a Web service as a "software system designed to support interoperable machine-to-machine interaction over a network" (Haas/ Brown, 2004). These Web services have an interface described in a machine-processable format and other systems interact with the Web service in the manner prescribed by its description using standardised messages. In the technology-specific approach, a Web service commonly refers to an implementation using the so called "Web service technology" comprised of WSDL, SOAP, and XML. However, Web services could also be implemented using other technologies such as CORBA. To avoid the confusion between the technology-free and technology-specific interpretation, in a computer science context the term service is used to refer to the technology-free interpretation, while Web service is used to refer to the particular technology using WSDL, SOAP, and XML.

Working Definition For the purpose of this work a service will be defined as a *business activity of value exchange that is accessible through an electronic interface.* In that sense a service as it will be understood within the context of this work lies at the intersection of the business definition of a service (i.e., business activity of value exchange) and the technical implementation of a Web service. Such a service is more than the pure technical implementation of a Web service or another software implementation. The service has to implement a business activity that a user attributes value to. Yet services delivered in a non-electronic fashion, like services offered by hospitality, are not within the scope of this work. Accessibility through an electronic interface refers to an understanding in the broader sense of the word and includes the coordination or arrangement of something physical through an electronic interface (including an electronic user interfaces). Such a service may be provided through a single implementation of a Web service or through a collection of Web services that together form a new value added service which is then delivered through an electronic interface. If the intention is to specifically refer to the business definition of a service or to refer to the technical understanding of a Web service, this will be explicitly marked in the remainder of this work. When stressing the difference between electronic and non-electronic services, the term e-service will be used to highlight the electronic nature. Otherwise the term “service” refers to an electronically accessible service as defined by this working definition.

3.2 What Makes E-Services Different?

We argue that certain distinct characteristics of electronic services mandate a customised service development approach for these e-services, as opposed to traditional NSD. Through an analysis of existing research related to electronic services, we identified five key areas of difference (Riedl/Leimeister/Krcmar, 2011): 1. the cost structure of services, 2. the high degree of outsourcing, 3. the rapid development of new services, 4. the availability of transparent service feedback, and 5. the continuous improvement of services. The following sections discuss each area of difference.

3.2.1 Low Marginal Costs of Service Delivery

The economics of information have been recognised as being dramatically different from the economics of physical items (Lamberton, 1992; Evans/Wurster, 2000). This leads to a unique cost structure both in comparison to physical products as well as to other non-electronic services.

The typical cost structure of an information technology supplier involves high fixed costs for developing the infrastructure and applications, and very low, sometimes near zero, marginal costs for actual service provision (Whinston/Choi/Stahl, 1997; Bakos, 1998; Sambamurthy/Bharadwaj/Grover, 2003). Once an e-service has been developed and the infrastructure is in place, they are almost infinitely scalable with minimal effort (Menor/Tatikonda/Sampson, 2002). Through the use of electronic intermediaries, the search and transaction costs of e-services are reduced even further (Bakos, 1998) resulting in low variable costs of service provisioning and service use. Contrary to non-electronic services that are sometimes very labour intensive (e.g., hospitality services), the costs for e-service delivery are marginal and the main costs accrue during service design, as opposed to service delivery. This difference should explicitly be addressed during service development.

3.2.2 High Degree of Outsourcing

Outsourcing is a standard concept that is being considered through make or buy decisions both in manufacturing and in services (Dibbern et al., 2004). In electronic services, outsourcing plays a particularly important role. First, since service provisioning occurs in the back office and electronic services can easily be delivered from remote locations, there is no need to collocate service production with the service consumption (Miles, 2005). Traditional services do not enjoy this opportunity, e.g., through the need of attractive locations (think of a down-town café). Second, the high degree of technical standardisation achieved through various Web service standards (Champion et al., 2002) and efforts to standardise service-oriented architectures (Beisiegel et al., 2005), this high degree of outsourcing is accompanied by the necessary technical framework to make outsourcing of individual service components feasible. Furthermore, coordination costs are extremely low which enhances the ability to combine digital products to create new value which increases the focus on re-use and outsourcing (Sambamurthy/Bharadwaj/Grover, 2003; Malone, 2004; Sankaranarayanan/Sundararajan, 2010). Here, information technology drives the modularisation and atomisation of business processes and enables their combination and recombination to create new business processes and services (Malone et al., 1999). This is additionally fostered through the increased availability of high-speed networks.

The technical standardisation allows the easy integration of other providers' components and services. This can result in a network of actors that combine several service components to create composite service offerings, e.g., travel services integrating flight, hotel, local transportation, and other reservation services. Once these services are integrated through the development of appropriate interfaces, infinite re-use of existing components with no further integration or assembly costs is possible. However, this can result in complex value networks with different actors working together in a federated service environment. This leads to complex value constellation in distributed networks which are harder to manage with the increased number of involved actors (Vanhaverbeke/Cloodt, 2006; Leimeister et al., 2010).

3.2.3 Rapid Development of New Services

Virtually every aspect of life is accelerating at a faster pace (Gleick, 1999). This global development also impacts NSD. As services can be copied easily and are not applicable to patent protection it becomes increasingly difficult for organisations to differentiate themselves through the services they offer. This makes following a differentiation strategy difficult (Porter, 2001; Hipp/Grupp, 2005). Consequently, only continuous innovation can lead to economic success. However, these effects, common to all services, are magnified in the area of electronic services. Advances in electronic services are particularly rapid, and low barriers of entry have been attributed to electronic services (cf. Porter, 2001; Menor/Tatikonda/Sampson, 2002; Evans/Wurster, 2000). Reasons for the lower barriers of entry are, for instance, the increased scalability of e-services, global markets due to the global availability of information and accessibility of services, and difficulties in regulating global communication networks (Menor/Tatikonda/Sampson, 2002). This rapid development is further fuelled by extremely fast technological progress and the rapid emergence of new technologies. A key driver of the fast rate of innovation being the modular architecture found in the computing industry (Baldwin/Clark, 1997; Baldwin/Clark, 2000). This fast technological progress not only creates opportunities for new service concepts, but also affects customers' expectations and preferences which require constant innovations to meet them (e.g., all the electronic services offered on the Apple iPhone App Store[1] which was

[1] `http://www.apple.com/iphone/apps-for-iphone/` (last accessed 2010-10-26)

only just created through the advances in mobile phone technology). Furthermore, the very nature of electronic services benefits radical innovation through major innovations and start-up businesses (Menor/Tatikonda/Sampson, 2002; Johnson et al., 2000).

3.2.4 Transparent Service Feedback

Through the electronic nature of service delivery, the interaction between a service consumer and the service itself becomes very transparent. A simple example of this effect is the monitoring of click-through-rates in online shops. In general, the electronic nature of service interaction allows the passive collection of customer feedback (Sampson, 1996). This generates a nearly complete picture of customer interactions which a traditional shopping mall operator would dream of. This creates various opportunities for service design and innovation where interactions between users and the service can be recorded and replayed. Thus, a service itself can gather information about what else users might want or need (Riedl et al., 2008).

The transparent nature of service feedback is also an option for new business models based on new licensing schemas. As the usage information is transparent to providers, billing is possible, based not only on the actual use but on the value generated for the customer. For example, instead of charging for a customer relationship management (CRM) service based on concurrent users, charging based on the actual revenue generated through the CRM service would be possible.

3.2.5 Continuous Improvement and Deployment

Unlike software being sold over the counter, electronic services are no longer restricted to a scheduled release cycle where changes, improvements, and bug fixes require months to be integrated into the service (termed “perpetual beta” by some authors, cf. O’Reilly, 2007; Morris, 2006). Rather, services are developed in the open with tight integration of service users or even by the users themselves. For example, services like the Google search and many of the online applications are constantly updated. There are no distinct releases with version numbers assigned to the service instance currently offered; rather, improvements slip into the market almost unnoticed. The innovation process is also full of small cycles that allow a service to be improved almost instantly (O’Reilly, 2007). Additionally, as services are delivered through a global delivery system, there are no local differences in the services offered and the new version is instantly available to all users. This would be very hard to implement for non-electronic services where physical facilities need to be upgraded and personnel need to be trained.

This has two fundamental effects on the development of new electronic services. First, the benefits of perpetual beta and continuous improvements can be used to upgrade services with the improvements instantly visible to all users. Second, service providers have to make sure that improvements are visible to users and are valued as such in order to elicit the impression of sustained innovation.

The following section analyses established NSD literature with particular focus on how the specific characteristics of e-services are addressed.

3.3 New Service Development for Electronic Services

With an increasing importance of the service sector, the management of new service development is becoming a key competitive concern for many companies (Gallouj/Weinstein, 1997; Johne/Storey, 1998; Johnson et al., 2000; Fitzsimmons/Fitzsimmons, 2000; Menor/Tatikonda/Sampson, 2002; Gallouj, 2002). Despite its importance, it is not well understood and ranks behind the research on new product development (NPD) (Menor/Tatikonda/Sampson, 2002).

Section 3.2 derived a set of five key attributes that distinguish electronic from non-electronic services and their potential influence on NSD. These key attributes are used as a framework for analysing NSD literature with regards to their applicability to inform the development of new e-services. This section presents a systematic literature review of NSD research with regards to how e-services can be developed.

3.3.1 Analysed Aspects

Based on the key differences between electronic and non-electronic services elaborated in Section 3.2 and their impact on the new service development process, we derived a set of questions to guide our literature review (Figure 3.1). These questions have been used to review existing literature regarding their suitability for guiding the development of new e-services.

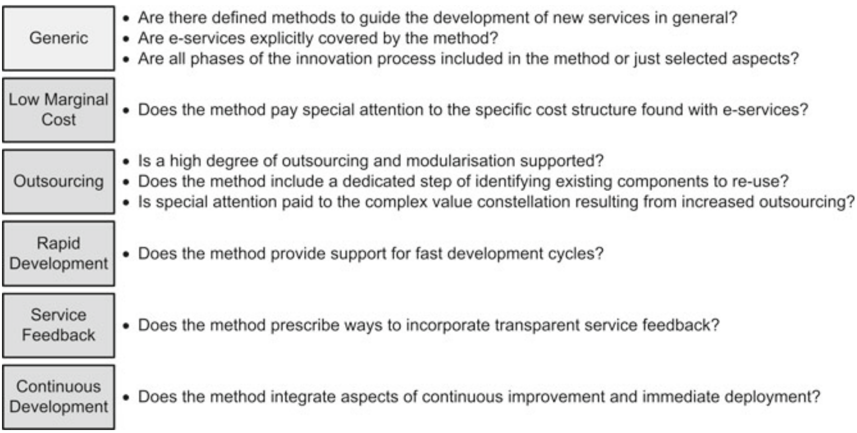

Figure 3.1: *Questions guiding the NSD literature review and the area of difference they originate from.*

The following sections review the literature in the area of NSD with regards to their prescriptive support for designing and developing electronic services. Special attention is paid to those aspects distilled above that are unique to electronic services, compared to non-electronic services.

3.3.2 Analysed Literature

A systematic literature review was performed with the initial search using the key words “new service development” or “NSD” on the online databases ScienceDirect and EBSCO-host which covered a broad range of high-quality, peer reviewed publications. The review time period was from 1997 to 2008, as NSD research received significant attention during this time (Zhou/Tan, 2008). The initial search returned over 300 articles. Accounting for duplicate results and after a preliminary scan of the article abstracts, the number of articles to be included was substantially reduced. Reasons for excluding articles were, among others, a different understanding of e-service that related more to information system adoption, or articles that simply referred to NSD literature or used NSD methods but did not contribute to the extension of NSD research itself. Moreover, we included several cross-referenced articles and books absent in those databases and a comprehensive review of relevant academic journals that we expected to have published articles on NSD. Finally, 63 relevant journal and conference articles, as well as books and book chapters, were included in the review. Table 3.2 gives an overview of the publications by year and Table 3.3 gives a summary of the top journals included in this review. In addition to these journals, there were also 11 books/book chapters, and four conference papers included in the review. The remaining 18 articles were from other journals that contained only one or two papers on NSD.

The literature on NSD focused mainly on success factors and the development of (process) models, as well as a large set of summary and review-based articles. The topics covered in the analysis and the number of articles that predominantly deal with this topic is shown in Table 3.4. A similar distribution of main themes covered in NSD research has also been reported by Zhou/Tan (2008) and in an earlier review by Menor/Tatikonda/Sampson (2002). The analysed literature spans across varied sectors of activity. Table 3.5 provides an overview of the distribution across service sectors. In particular, many of the process model papers have been developed in a sector neutral way or through multi-sector research.

Year	*Frequency*	*Year*	*Frequency*
1997	5	2003	6
1998	2	2004	5
1999	0	2005	5
2000	10	2006	6
2001	4	2007	8
2002	5	2008	7

Table 3.2: *Publications by year.*

Journal	*Frequency*
Journal of Operations Management	6
Research Policy	6
Journal of Product Innovation Management	4
European Management Journal	3
e-Service Journal	3
European Journal of Marketing	3
International Journal of Service Industry Management	3

Table 3.3: *Top journals included in analysed literature.*

NSD Research Theme	*Frequency*
Types of service innovation	10
Antecedents of success	24
Process models	11
Generic and organisation related issues (including literature reviews)	18

Table 3.4: *Overview of topics covered in the analysed articles.*

Sector	*Frequency*
Sector neutral	21
Multi-sector	20
Financial	7
Healthcare	4
Telecommunication	3
Hospitality	2
Retail	2
Other	4

Table 3.5: *Sector distribution of analysed literature.*

New Service Category	*Description*
Radical innovations	
Major innovation	New services for markets as yet undefined; innovations usually driven by information and computer-based technologies.
Start-up business	New services in a market that is already served by existing services.
New service for the market presently served	New service offerings to existing customers of an organisation (although the services may be available from other companies).
Incremental innovation	
Service line extensions	Augmentations of the existing service line such as adding new menu items, new routes, and new courses.
Service improvements	Changes in features of services that are currently offered.
Style changes	Modest forms of visible changes that have an impact on customer perceptions, emotions, and attitudes, with style changes that do not change the service fundamentally, only its appearance.

Table 3.6: *A typology of new services (adapted from Johnson* et al.*, 2000).*

3.3.3 New Service Development

NSD involves the development of service offerings such as financial services, health care services, telecommunications services, leisure and hospitality services, information services, legal and educational services, and many more (Johne/Storey, 1998). Contrary to new product development which is regarded as a base for much research in this area, NSD stresses core differences between products and services: intangibility, heterogeneity, and simultaneity (Fitzsimmons/Fitzsimmons, 2000). Despite a growing body of knowledge, our understanding of NSD processes, especially for electronic services, is still limited (Menor/Tatikonda/Sampson, 2002).

The following sections analyse NSD literature with regards to the five key areas of differences and the analysis framework presented above. The analysis sections are structured along the four main topics areas identified in NSD literature: 1. types of service innovation, 2. antecedents of success, 3. process models, and 4. generic and organisational aspects.

3.3.3.1 Types of Service Innovation

The first set of articles tries to bring structure to the types of innovations found in services by proposing typologies of service innovation. Edvardsson/Olsson (1996) suggest that service innovation includes the development of 1. a service concept (which customer needs are satisfied), 2. a service system (the resources necessary to deliver a service), and 3. a service process. These three areas make service innovation a complex and multidimensional undertaking (Essen/Conrick, 2008).

Johnson et al. (2000) suggest six categories to structure service innovation (Table 3.6). Other types of service innovation noted are, for example, the new combinations of existing services or the combination of customer co-production with new service characteristics or competencies (van der Aa/Elfring, 2002; Gallouj/Weinstein, 1997). It has been noted that many e-services are new versions of existing services (e.g., online procurement). Thus, external newness of e-services is sometimes low (Menor/Tatikonda/Sampson, 2002). Understanding different types of innovations is critical as it affects the management of innovation because no single organisational structure is effective in all circumstances (Tidd, 2001). Hipp/Grupp (2005) identify four patterns of key factors influencing service innovation: knowledge intensity, network basis, scale intensity, and supplier dominance. Especially the network-based innovations seem to match most electronic services due to their reliance on technological systems for information and communication processing. Menor/Tatikonda/Sampson (2002), moreover, argue that the nature of electronic services especially benefit radical innovations (major innovations and start-up businesses). While there is agreement in the literature that different types of new services exist, there is little agreement as to what these types are. In particular, new types of e-services have not been studied systematically. Consequently, developing a better understanding of the types of new e-services and their appearance in the marketplace would be necessary to advance the field of e-service research.

Barras (1990) argues that IT-based service innovation follows a pattern that is different from that found in manufacturing. He claims that in the early life-cycle phase of a service "technology push" is the main driving force, whereas in the following phases incremental process innovation through "demand pull" is the driving force. In the latter phase, pressure by users increasingly forces service providers to distinguish themselves, leading to differentiated products and product innovation. To account for this fact and the specifics of service industries, Barras (1990) proposes a reverse product life-cycle (RPC) model for services. The reverse product life-cycle model suggests that innovation takes place in three phases: improved efficiency, improved quality, and new services phase. This model could help in explaining e-service innovations, as these are obviously largely IT-based and often follow new technical innovations. Other articles also discuss the specific influence of IT innovations on service innovation. The process innovation aspects achieved through the use of IT in back-end service provisioning and automation potentials are especially notable (Miles, 2005). However, these types of innovation are not specific to e-services, as IT is a technology to be applied to the generic information-processing activities of services (Miles, 2005). Miles concludes that a study of IT influence does not reveal much about the dynamics and processes of innovation.

None of the studies cited above, taken from diverse industries, explicitly addresses electronic services. There is also an established hypothesis that innovation patterns in services are less sector-dependent, and that every type of innovation can be found within each individual service industry. In particular, there is no specific industry or service sector to offer electronic services per se. As IT plays an important role in most industries, and computing concepts such as service-oriented architectures are increasingly adopted, e-services cannot be attributed to a specific industry. Moreover, knowledge insensitivity does not necessarily imply that the service is delivered electronically. For example, many financial services, though highly IT-based, are not electronic. Yet an electronic ticket reservation service offered by an airline is. As Miles (2005, 440) notes, "[s]ome online information services originated from in-house data management services, e.g. from publishing firms."

This makes studying e-services more difficult, as they occur in all industries and service sectors. Establishing a common understanding about e-services across the diverse industries and service sectors is a desirable goal.

3.3.3.2 Antecedents of Success

Related to the different types of innovation, a substantial part of the literature addresses the question of what are NSD antecedents of success (de Jong/Vermeulen, 2003). Two classes of success factors can be distinguished: NSD outcome factors (how successful is the new service - the outcome of the NSD process) and performance measures of the NSD process itself (Voss et al., 1992). Table 3.7 summarises a sample of these metrics.

Generic antecedents include strategic fit, skilled front-line employees, high-involvement teams, clear project structure, formal processes, top management support, and product champions (de Brentani, 2001; Vermeulen/van der Aa, 2003; de Jong/Vermeulen, 2003). Stevens/Dimitriadis (2005) report that NSD is especially successful when learning occurs during the development process. Further, two evolutionary stages of "manage key activities" and "create a climate for continuous innovation" have been identified (de Jong/ Vermeulen, 2003). In an analysis of the antecedents of NSD success, IT systems and process structure have been shown to have a positive impact on the speed of NSD processes (Froehle et al., 2000). As NSD speed is of particular importance for e-services, this is a valuable contribution. Another notable contribution can be found in Menor/Tatikonda/ Sampson (2002) who did not study e-service antecedents of success but proposed that the aspect of external newness is especially salient, as electronic services are often replications of services already known to customers but are now offered in an electronic way. Although none of the studies explicitly addressed electronic services, it can be assumed that these antecedents are generic enough to play an important role for electronic services as well.

Analysing the specifics of e-services, some individual studies can be found. These studies are, however, very sector specific at times and do not address the development of e-services at a broader level. For example, Vassilakis et al. (2005) studied barriers to e-service development of e-government services. They found legislative, administrative, technological, user-culture, and social barriers to hinder the development and introduction of e-services in the e-government domain. Similar studies of success factors have, for example, been performed for e-services in retailing (e.g., Rose/Straub, 2001) or e-health (e.g., Lankton/Wilson, 2007). In a study analysing the development of one online retailing and one online information service related to sports, Ozer (2008) finds task structuring and expertise sharing during development two important predictors of service success. A quite established field is the measurement of service quality of website-based e-services, such as online shopping (e.g., Parasuraman/Zeithaml/Malhotra, 2005). Here, various quality metrics can be found that can guide the development of e-services. While some generic antecedents of success are known and seem applicable to the field of e-services, the antecedents particular to the development of new electronic services are scattered. Investigating in greater detail the antecedents of NSD performance that are particularly important to NSD of e-services (in particular speed of development) would be necessary to gain a better understanding of e-service development.

NSD Outcomes	*NSD Process*
Financial measures Achieving higher overall profitability Substantially lowering costs for the firm Performing below expected costs Achieving important cost efficiencies for the firm	*Criterion cost* Average development cost per service product Development cost of individual service product Percentage of turnover spent on developing new services, products and process
Competitive measures Exceeding market share objectives Exceeding sales/customer use level objectives Achieving high relative market share Having a strong positive impact on company image/reputation Giving the company important competitive advantage	*Effectiveness* How many new services developed annually Percentage new services that are successful
Quality measures Resulting in service "outcome" superior to competitors Resulting in service "experience" superior to competitors Having unique benefits perceived as superior to competitors Great reliability More user friendly	*Speed* Concept to service launch time Concept to prototype time Prototype to launch time Time to adopt new concept from outside the firm

Table 3.7: *Measures of NSD outcome and process performance (adapted from Voss* et al.*, 1992).*

The electronic nature of e-services has specific influences on the NSD process. Related to antecedents of success, the introduction of new service versions that are continuously released to customers is likely to have a major influence. Only if the increased service quality is perceived as such by service consumers, has the development process been successful. This leads to the question of how the continuously improved service can be successfully marketed to customers so that they are aware of the increased service quality.

3.3.3.3 Process Models

With regards to traditional services, NSD can be seen as a rather complete method covering all phases of the service life-cycle. There are, in particular, a wide set of process models defined for the development of new services. In a comparative study of existing NSD literature, Johnson/Menor (1997) propose a basic model of four phases: design, analysis, development, and launch. Although models included in the literature review did not match precisely and different phases were more detailed in some models and more succinct in others, these four phases were found in all.

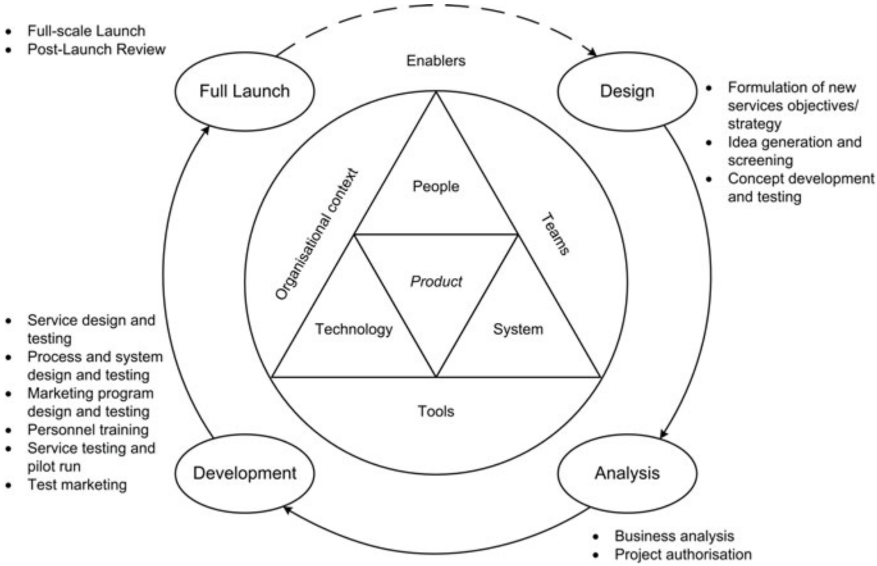

Figure 3.2: *NSD process cycle (adapted from Johnson* et al.*, 2000).*

More recently, Johnson et al. (2000) have developed a NSD process based on four broad stages and 13 detailed tasks to produce and launch a new service. The model emphasises the *nonlinearity* of the NSD process through a continuous cycle, as well as the importance of enabling factors: teams, tools, and organisational culture (Figure 3.2).

On a very generic level, Bessant/Davies (2007) suggest that organisations have to manage four phases in the innovation process: search and scan their environment to pick up signals for potential innovation, strategically select those ideas that the organisation will commit resources to, implement the innovation, and finally reflect on the previous phases to achieve organisational learning. What is not covered in these process models are the increased options for modularisation, re-use, and outsourcing available for e-services.

In new product development literature, designing products in such a way that they can easily be manufactured (i.e., contain fewer parts and have minimal complexity) has been addressed (Swink, 1998). A similar issue has also been addressed in NSD as "design for delivery" hoping to reduce the costs of service delivery (Bullinger/Fähnrich/Meiren, 2003). As many services are highly labour intensive (e.g., hospitality services), the motivation to optimise services for efficient delivery is high. As electronic services follow a reversed cost structure as explained above, these approaches are not suitable for e-service development. On the contrary, it would be necessary to further analyse how the costs of developing new e-services can be reduced. As the early phases of the development process, specifically the design and analysis phase, are particularly expensive (Bullinger, 2008), they offer potential for improvement.

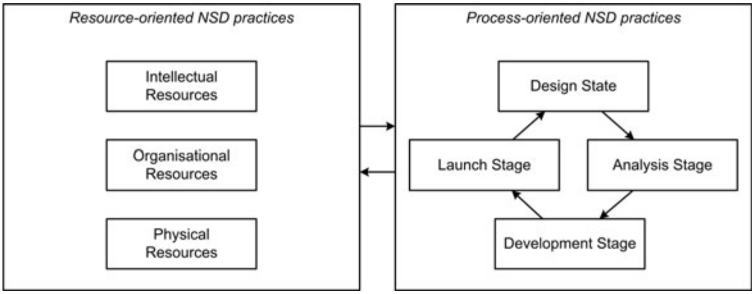

Figure 3.3: *The Resource-Process framework (adapted from Froehle/Roth, 2007).*

A related issue is the common distinction in service development between a "front-office" and "back-office" (e.g., Metters/Vargas, 2000). Yet, sole focus on "back-office" operational efficiency is not enough and has been neglected with many e-services. As argued by Riedl et al. (2008), perceived quality measures have to be taken into account to address satisfaction issues commonly addressed in "front-office" design. Moreover, Johnson et al. (2000) note that different NSD processes are necessary for different types of innovation. In particular, they identify incremental service innovations, radical service innovations, and technology-driven services as key differences that should be used to choose the appropriate NSD process; the authors propose this as an avenue for future research. With regards to the perpetual beta aspect of electronic services, this result might be useful in guiding the selection of a specific process that is designed especially for incremental innovations (de Brentani, 2001).

Froehle/Roth (2007) propose a framework for NSD that integrates both process- and resource-oriented approaches. The resource-oriented practices focus on cultivating and developing the intellectual, organisational, and physical resources that support NSD capabilities. The process-oriented practices focus on planning, defining, and executing the actual stages of the service development (Figure 3.3). Their belief and motivation for this integrated view is that both resource and process capabilities are required for successful service development.

Pavitt (2005) acknowledges that services have to be continuously improved and that a continuous mapping of service artefacts to market needs and demands is necessary. However, there is no consideration for the vast transparent feedback available in e-services and the very fast cycle times. Concepts such as systematic and large scale customer integration (e.g., through open innovation), as well as and customer co-design, offer opportunities for the design and customisation of e-services. The integration of approaches like agile software development, mash-ups, open innovation, and participatory Web 2.0 concepts could provide a fruitful avenue for adapting NSD processes to the requirements of e-service development. Addressing this research objective could serve two purposes. First, it could leverage on the electronic nature of e-services that make them particularly suitable for customer co-designs, as they are largely information based. Second, the integration of customers could help in reducing design and development costs, thus addressing the reversed cost structure found in e-services.

3.3.3.4 Generic and Organisation Related Issues

The last topic area that has been identified analyses how NSD is performed within an organisation. NSD has been addressed on different organisational levels, including project teams, business units, complete organisations, and networks of organisations. In this research, issues such as the role of managers and the influence of external factors (i.e., those of a creative environment) have been addressed.

Syson/Perks (2004) address network issues in NSD. They conclude that interactions are critical for NSD and that the incorporation of disparate perspectives is beneficial (i.e., they increase creative potential) and that the network perspective helps incorporate relevant resources and actors. However, the very nature of services (intangibility, heterogeneity, and inseparability) brings considerable complexities to the exchange processes of NSD. As services are copied easily, the development of a network approach to NSD could provide firms with a source of competitive advantage. They do not, however, address the management of the resulting complex value networks. Given the positive impact that organisational learning has on NSD success (Stevens/Dimitriadis, 2005) and the increased network character of e-services due to their suitability for re-use and outsourcing, studying organisational aspects and the management of joint NSD in value networks are of particular importance. However, organisational aspects and how the network character of e-services influences the NSD process and success factors are not clearly established in research.

3.3.4 Research Gap

NSD is a rather complete method describing key processes and tasks. Moreover, it covers all phases of the life-cycle from design, analysis, and development to launch, as is apparent from the wide collection of process models that have been reported. Especially noteworthy is the cyclic model of Johnson et al. (2000). However, the design of electronic services is not explicitly covered except in articles offering basic definitions of e-services. A notable exception is the article by Menor/Tatikonda/Sampson (2002) that shows gaps that exist and points to research challenges.

While several research results indicate successful development of e-services, there are certain gaps in NSD research with regards to key attributes of electronic services and their influence on NSD. In particular, current NSD methods are not well equipped to address the rapid nature and specific cost structure found in electronic services. Moreover, current NSD methods are not well suited to fully exploit the various advantages offered by electronic services over non-electronic services (cf. Section 3.2). These are, in particular, the transparent feedback generated by service usage, and the potential for continuous improvement and rapid deployment of service changes.

This review of the literature shows that e-service specific aspects have no isolated effects on NSD. The effects are all interlinked and have implications for the types of innovation, success factors, processes, and organisational aspects alike (Figure 3.4). Thus, existing NSD practices need to be adapted and tailored to meet e-service specific aspects in a

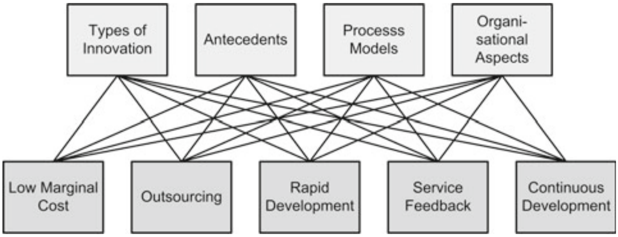

Figure 3.4: *Influence of e-service attributes on NSD areas.*

general way. Table 3.8 puts the e-service characteristics in relationship to the mayor NSD research areas. Some of the key characteristics of e-services that pose the main challenges for NSD also contain parts of the answer. For example, the need for increased speed of development can be addressed through e-service capabilities for continuous development and the availability of transparent user feedback. This implies, however, that only if the new opportunities provided by the electronic nature of e-services are harnessed, can the challenges be successfully overcome. This hints at the possible necessity of integrating developments in diverse areas (software engineering, process management, open innovation, Web 2.0 and participatory development, or information management) into the NSD process for e-services in a more systematic way.

In summary, the research on electronic services in general and the development of these services in particular, despite its increasing importance, is still limited. This chapter provides an initial basis by elaborating upon the key aspects that distinguish non-electronic from electronic services, and points to gaps in the literature to frame the contribution of this research. The following box summarises the contribution of this work in the area of NSD.

Research Gap - Contribution of this Work to Field of NSD
This work contributes to NSD research by investigating and extending current NSD methods to the development of electronic services, particular in the context of networked organisations offering and developing services cooperatively.

3.3.5 Criteria for a Solution

The presumptions in form of a developed research gap between the methods provided by established NSD research and the characteristic attributes of electronic services are summarised as criteria for a solution to provide tool-supported innovation management for the systematic development of electronic services. Furthermore, the consolidated findings from established NSD research have been integrated.

Electronic services have a unique cost structure both in comparison to physical products as well as to other non-electronic services so that a majority of the costs accrue during the development of a service and not during service operation (Evans/Wurster, 2000; Sambamurthy/Bharadwaj/Grover, 2003). As the literature review has shown this is not

		Key Characteristics of E-Services				
		Low Marginal Costs of Service Delivery	**High Degree of Outsourcing**	**Rapid Development of New Services**	**Transparent Service Feedback**	**Continuous Improvement and Deployment**
Areas of NSD Research	**Types of Service Innovation**	New types of service innovations emerge: Bundling and composite services, as well as mass-customised services.	Aggregator services and service bundles as well as service customisation through re-use are new types of service innovations.	Depending on the type of innovation the development process needs to be customised towards speed or quality.	Transparent service feedback benefits incremental service innovations.	As minor improvements are easy to deploy, customer benefits of these improvements needs to be communicated through marketing.
	Antecedents of Success	Process success is important as costs accrue during design not delivery. Services for small markets can be successful if they can be developed and launched efficiently (long-tail).	Joint development and partner integration is likely to play a bigger role as value networks and service ecosystems form.	Quickly changing customer expectations need to be met through rapid development of new services.	Customer integration is key to success - through the transparent service feedback this is even easier.	Minor service improvements need to be made visible to customer to ensure the success of the improved service.
	Process Models	Efficient service development becomes even more critical for success.	Outsourcing and re-use should be explicitly be integrated into the development process.	Process models need to be tuned for speedy development of new services.	Integration of feedback into process is becoming easier as feedback is readily available.	Process models need to be cyclical and support the continuous improvement and deployment of new services.
	Generic and Organisation Related Issues	NSD competency, organisational learning and organisational resources become more important as differentiation through service delivery is limited.	Network management and the management of organisational learning across partners and NSD projects becomes more important.	Organisations need to adapt to, and be able to deliver on the shorter service life cycles and the increased speed of development.	Customer feedback, both implicit and explicit, needs to be incorporated into organisational learning.	The continuous development character needs to be reflected by continuous improvement and learning of the developing organisation.

Table 3.8: *Relationship of key e-service characteristics with major NSD research areas.*

sufficiently addressed in current NSD approaches. Furthermore, through the electronic nature of service delivery the interaction between a service consumer and the service itself becomes very transparent. Thus, a service itself can gather information about what else users might want or need (Riedl et al., 2008). Consequently, to exploit this opportunity of service feedback offered by electronic services an innovation management tool for service ecosystems needs to support the full service life-cycle and not only the innovation related phases. This would also be necessary to allow learning to occur during the development process which has been identified as a key success factor (Stevens/Dimitriadis, 2005). A similar requirement has been proposed by Oberle et al. (2009, 380).

Criterion 1: Support the full service life-cycle, not just the innovation phase.

Fast development cycles are particularly important in the area of e-services which are not sold over the counter as software but changes, improvements, and bug fixes can be released immediately and globally which lead to the coinage of the term "perpetual beta" (O'Reilly, 2007). Virtually every aspect of life is accelerating at a faster pace (Gleick, 1999). Services are increasingly developed in the open with tight user integration or even by the users themselves. The innovation process is full of small cycles that allow a service to be improved almost instantly. To make use of these benefits of electronic service development it is necessary to support the complete service life-cycle from design through implementation to service usage and make all innovation related data available across all innovation phases. Consequently, e-services should be developed in nonlinear, cyclic process. Furthermore, the cyclic and dynamic processes should be configurable to flexibly adapt the process depending on the type of innovation being developed (radical vs. incremental innovation). This would allow deviating from a formal process depending on the type of innovation (de Brentani, 2001).

Criterion 2: Support different phases of the innovation process, organised as cycles that are rapidly repeated.

3.4 Service Ecosystems

E-services have become extremely popular in recent years and the success of business models centred on e-services such as Amazon.com, Google, and salesforce.com demonstrate the real commercial success of these models. Building on their wide-spread use new composite services are created that span across business boundaries in order to implement end-to-end business processes. This phenomenon of a large collection of services has been described as a *service ecosystem* (Barros/Dumas, 2006). A key aspect of service ecosystems is that their exposure and access are subject to constraints characteristic of business service delivery (Barros/Dumas, 2006).

Service ecosystems take the idea of interconnected services even further by putting constraints on the service delivery at a business level. As envisioned by Barros/Dumas (2006) in these service ecosystems, service providers of basic, or core services, could augment their services by distribution and delivery functions made available to them by the ecosystem (Figure 3.5). For example, such an ecosystem could provide payment and metering facilities that can be used by other providers to extend the functionality of their services.

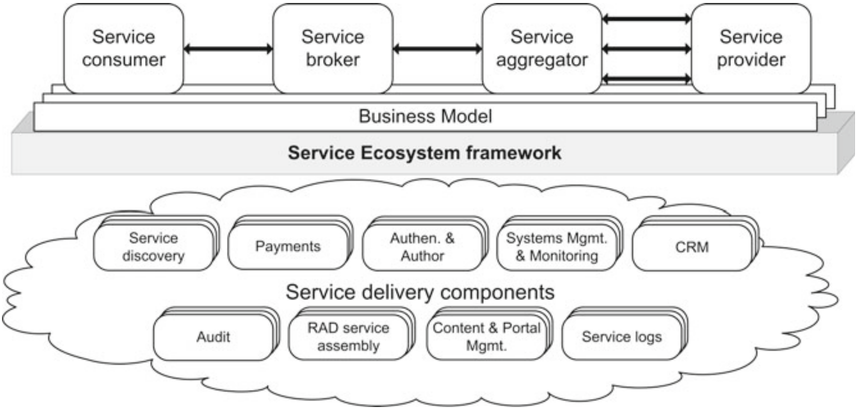

Figure 3.5: *Top-level architecture of a service ecosystem (adapted from Barros/Dumas, 2006).*

Service brokers bring service providers and service consumers closer together. They might also integrate a service with certain delivery functions such as payment and authentication or combine several core services into a completely new offering. Service aggregators combine existing services to create new service offerings (Barros/Dumas, 2006). Through the flow from service providers, aggregators, and brokers a service is finally offered to the service consumer. This interplay of supply and distribution roles is shown in the top layer of Figure 3.5. Service ecosystems thus offer a business view on services as opposed to the more technical view taken by service-oriented architectures.

The interplay of supply and distribution roles and the resulting networked structure in which services in service ecosystems are offered have several implications on service delivery and quality aspects (Riedl et al., 2009b). First of all, this leads to a separation of service provisioning and service delivery. A (core) service provider might no longer be responsible for the actual service delivery to a service consumer. At least the service provider might not be responsible for service delivery in every possible channel and in all service combinations as new markets and delivery channels are tapped into through reselling and brokerage. Moreover, third party delivery intermediaries (e.g., payment engines, authentication services, auction boards) augment services in ways that might not have been foreseen by the service provider. Hence, services might be delivered to new customers through new channels in unforeseen ways, which consequently leads to potentially new quality requirements. The implications of these aspects on the quality of service delivery have been discussed in detail by Riedl et al. (2009b).

A growing interest in academic research is emerging as a consequence (Barros/Dumas/Bruza, 2005; Wu/Chang, 2005; Barros/Dumas, 2006; Sawatani, 2007; Stathel et al., 2008; Riedl et al., 2008; Kohlborn/Korthaus/Rosemann, 2009; Riedl et al., 2009b; Riedl et al., 2009a). Although the terms used may differ, phenomena similar to service ecosystems have been researched in other areas, for example under the label

- “Service Value Network” (e.g., Basole/Rouse, 2008; Blau et al., 2009),
- “Business Webs” (e.g., Tapscott/Lowy/Ticoll, 2000; Steiner, 2005), and
- “Internet of Services” (e.g., Zhang/Chen/Zhou, 2005; Schroth, 2007; Dorn et al., 2007; Heuser/Alsdorf/Woods, 2008; Janiesch/Ruggaber/Sure, 2008; Ferrario/Guarino, 2008; Buxmann/Hess/Ruggaber, 2009; Oberle et al., 2009).

The metaphor of an *ecosystem*, the complex of a community of organisms and its environment functioning as an ecological unit, is common to describe (strategic) networks between organisations and is frequently found in business literature (e.g., Iansiti/Levien, 2004; Iyer/Lee/Venkatraman, 2006; Iansiti/Richards, 2006; Fox/Wareham, 2008; Zittrain, 2008; Tee/Gawer, 2009; Cusumano, 2010b; Kim/Lee/Han, 2010). In the context of service ecosystems it is used to refer to the collection of services that function together to implement end-to-end processes whereby each service provider benefits from the services offered by others.

The composability of existing services into new and innovative value added services that implement end-to-end processes is a central attribute of these ecosystems whereby services are provided and integrated by different actors of the ecosystem which leads to a division of supply and delivery (Barros/Dumas, 2006). Referring to this composability of electronic services, in particular in combination with semantic technologies, Parastatidis/Viegas/Hey (2009, 34) state: ”We believe that over time, a huge ecosystem of services and tools will emerge around data mesh instances.” Kohlborn et al. (2009; 2010a; 2010b) studied the special function of service aggregators and their role in offering innovative service bundles.

3.4.1 Actors in Service Ecosystems

This section introduces the different roles that can be found in service ecosystems. Barros/Dumas (2006) and later adaptations by Riedl et al. (2008; 2009b) and Kohlborn et al. (2009) propose that the following five actors have stakes in service ecosystems:

Provider Services are offered by service providers. These organisations provide the service implementation and offer the service by publishing a service description.

User/Customer Users request and invoke the services offered by service providers. These may be other applications (or other service providers) or the actual end-user of a service.

Broker Service brokers bring service providers and service consumers closer together. They might also integrate a service with certain delivery functions such as payment and authentication or combine other providers’ services into a new offering. The term *aggregator* is also used to refer to this role.

Mediator Service mediators offer translations between different service formats and other routine functions to allow service brokers to concentrate on their core competencies by eliminating the need for additional technical transformations.

Service Ecosystem Example: salesforce.com

As the concept of service ecosystems is new, the following paragraphs provide an illustrative example of an early service ecosystem. Salesforce.com (SFDC) is a provider of customer relationship software. Their business model, however, is to offer their software as a service and not for deployment within other companies (on-premise hosting). This software as a service model has been extended by salesforce.com to what they call "platform as a service." With their product AppExchange, SFDC aims at increasing the value for its complete ecosystem. Through its platform model, SFDC gives third party providers the possibility to offer their own services based on the salesforce.com platform. This includes tight integration into SFDC as well as hosting the application in a data centre that is provided by salesforce.com. For example, the service provider Print SF offers an application that allows users to create, print, and mail letters and other postal items. Thus, a value network between customers, salesforce.com, and various third-party providers is established (Figure 3.6). Currently there are over 1000 3rd party applications offered on the SFDC platform.

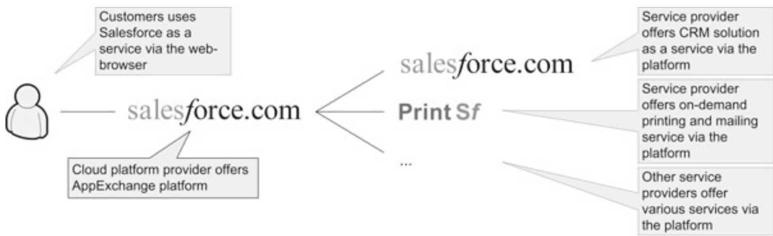

Figure 3.6: *Example of the salesforce.com value network.*

In general, SFDC follows a clear network strategy. In addition to 3rd parties offering services on their AppExchange platform there is also a network of partners providing consulting and sales, a network of customer exchanging data (sales leads mainly), and a customer community. This leads to a tight network structure on different layers (SFDC, customers, users, 3rd party providers, and partners). However, there is a clear star structure with most relationships running through SFDC (i.e., there are hardly any direct interactions between 3rd party providers).

SFDC's motivation for the platform strategy is also varied:

- Better utilisation of computing platform resources;
- Diversification: the open strategy allows SFDC to extend their reach by relying on niche players to provide specialised functionality that would be hard for SFDC to offer themselves;
- Access to external resources: SFDC's resources are limited. An open platform allows SFDC to grow quickly by relying on outside resources to offer new features;
- Concentrate on core competencies.

The platform and network established and operated by SFDC can be seen as an early instance of the "Internet of services," a service ecosystem.

Specialist Intermediaries These are providers in the more technical sense as they offer services but distinguish themselves through the nature of the service they offer. Contrary to "normal" providers they do not offer services targeted at end-users but rather offer service delivery components that are used by other providers to create marketable services. Common examples for these kinds of services are payment, authentication, or monitoring services. As such, specialist intermediaries interact mainly with other service providers as opposed to service end-users.

Another most obvious role, though not explicitly mentioned by Barros/Dumas is that of the *platform provider* that builds the overall platform on which the other actors operate. The platform provider offers, in particular, a service registry through which service providers can register their services to be discoverable by users. The role might include providing a computing infrastructure (such as Amazon's Elastic Compute Cloud EC2[2]) and a set of additional services such as payment or monitoring services. The main objective of the platform provider is the overall success of the entire platform. As such, a platform provider might choose to offer services that are unprofitable in themselves but are necessary to grow the general platform.

3.4.2 The Platform Business Model

The platform provider is the fundamental player in service ecosystems. It provides the central platform and market place where all other actors come together, trade their services, and interact with each other. The platform provides a central registry of services offered on the platform (Riedl et al., 2009a). Service providers can then register their services with the central service registry which can be browsed by customers to discover the services they need. Thus, the platform provider brings service providers and service consumers closer together. There are several options how the platform provider can generate revenue from the services provided through the platform. Most common, as in the examples of salesforce.com, the Apple App Store for the iPhone, or Amazon, is a fee or subscription based system: either for the provider to register the service, the service consumer to access the registry, or both.

As the example of salesforce.com earlier on showed, it is also common for the platform provider to offer its own services on the platform as well. These are often basic delivery functions necessary for third-party providers to create marketable services such as billing, payment, and monitoring services (Barros/Dumas, 2006). These platform services allow others to easily create tradeable services from their "raw" services. It is also quite common for the platform provider to offer infrastructure services as well (Böhm et al., 2010). In such a way, they hope to expand the range and portfolio of their platform by offering rather simple ways through which service providers can offer their services in a scalable and reliable fashion.

The aim of the platform business model is to increase value and revenue through attracting as many other providers and customers to interact through their platform and thus achieving network effects (Economides, 1996). They generate value through their broker-

[2] `http://aws.amazon.com/ec2/` (last accessed 2010-10-26)

ing activities of bringing supply and demand closer together as well as through their value added services that allow others to create service offering easily.

3.4.3 The Aggregator Business Model

Aggregation and composition are used to describe services that contain other services as sub-services (O'Sullivan/Edmond/ter Hofstede, 2002). In the business domain, an aggregation would comprise multiple services and provide access to them in a single location. Aggregation and composition are core characteristics of service ecosystems. Service aggregations are quite ubiquitous and can be found in business-to-business as well as business-to-consumer markets for products, services, and information (Tapscott/Lowy/Ticoll, 2000). Service aggregators are defined as "a service provider that groups services that are provided by other service providers into a distinct value added service" (Papazoglou/van den Heuvel, 2007, 407). Thus, service aggregators have a dual role. On the one hand, they offer the aggregated services and thus act as a service provider who can enforce their own policies for the aggregated service. On the other hand, they rely on external services offered by other parties within the ecosystem. Hereby, they act as a service consumer (Riedl et al., 2009b).

Similar to a digital retailer, aggregators choose suitable services that are offered by various service providers, make decisions about different market segments, determine prices, and control the transaction. Due to market volume and market power, aggregators can decrease their transaction costs and thus generate value. Aggregators can, for example, be found in the area of logistics where they allow their customers to outsource complete business processes.

In the aggregator business model, an entity acts as an intermediary between service consumers and providers. Through the aggregator role certain services are combined based on the aggregators detailed domain knowledge which adds additional value to the resulting aggregate service. The main goal is to offer services that provide a solution to a customer-specific need. Thus, aggregators re-brand, re-purpose, and re-factor services for a specific or anticipated customer demand. The value proposition includes selection, organisation, matching, price, convenience, and fulfilment (Tapscott/Lowy/Ticoll, 2000).

Related to the integration of data, a specialisation of the aggregator role is the data integrator. The data integrator operates under a similar business model as the aggregator but its focus lies more on the integration and provision of data rather than on the integration of service components. Data integrators would, for example, act as entities that "can transparently collect and analyse information from multiple Web data sources" (Madnick/Siegel, 2002, 36). This process requires in particular resolving the semantic or contextual differences in the information. Based on post-aggregation analysis where the integrated data is combined with the integrator's domain knowledge, value-added information is synthesised. Figure 3.7 shows a simple version of a possible value network including the platform provider and aggregator role.

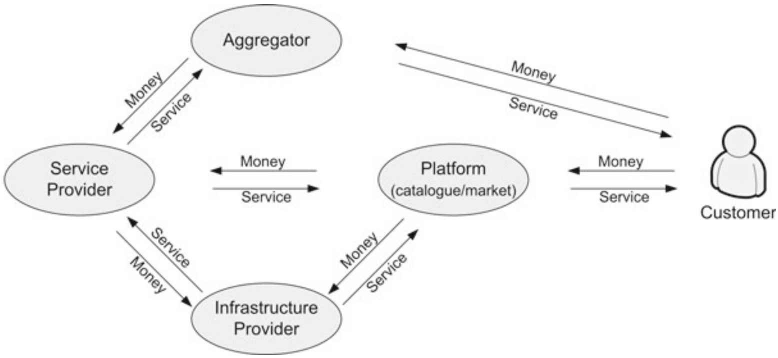

Figure 3.7: *Value network in a service ecosystem (adapted from Böhm* et al.*, 2010).*

3.4.4 Related Concepts and Foundations

Although the research on Internet of services and service ecosystem is just emerging, it shows the paradigm shift from a product- to a service-oriented economy and fosters the movement of complete industries from vertical integration to horizontal specialisation. Hierarchically organised firms start to cooperate in firmly-coupled strategic networks with stable inter-organisational ties forming flexible value networks with open structures that allow participants to focus on their strengths. Prominent advocates of this new paradigm are Hagel III (1996), Tapscott/Lowy/Ticoll (2000), and Steiner (2005). Existing theories from inter-organisational systems can be drawn on to explain these phenomena. Inter-organisational relationships of business firms are complex phenomena and as such difficult to conceptualise. However, there is a broad consensus that these systems can be best approached by factoring in economic, socio-political, structural, and technological variables (Bensaou/Venkatraman, 1996; Cunningham/Tynan, 1993). Many of these frameworks are modelled on industrial supply processes, such as in the automotive and retail industries, which have now been extended with processes for services delivered over the Internet.

In these value networks specialised firms co-opetitively contribute modules to an overall value proposition in the presence of network externalities. Zerdick et al. (2000) provide the following advantages of business webs related to modularisation and specialisation:

- concentration on core competencies strengthens specialisation;
- sharing the risk involved;
- high level of flexibility;
- modularisation brings potential for innovation and allows for rapid market penetration; and
- fruitful interplay of competition and partnership.

Specifically in the area of e-business Amit/Zott (2001) propose that the value creation potential hinges on four interdependent dimensions, namely: efficiency, complementarities, lock-in, and novelty. These potentials are a particular result of network externalities which can commonly be found in electronic services (Katz/Shapiro, 1985; Antonelli, 1992). Furthermore, one of the main effects of transacting over the Internet, or in any highly networked environment, is the reduction in transaction costs it engenders (Dyer, 1997; Dyer/Singh, 1998).

In the specific case of a service ecosystems, a value network formed around the delivery of services over the Internet, an additional advantage related to the "long tail" emerges (Anderson, 2006): because the cost of storing and distributing digital content is close to minimal, it is now reasonable for the providers of e-services to satisfy low-volume needs. Through an online platform for service ecosystems it becomes possible for small service providers to offer services on a global scale. On the other hand, service consumers get the chance to discover specialised services offered in the long tail. This implies that if development costs of new services can be kept low, even low-demand services can be a profitable business serving the long tail of customer demand.

The efficiency and effectiveness of cooperation between network member firms is often facilitated through the use of information technologies (Malone/Crowston, 1994; Dodgson/Gann/Salter, 2006). This makes developing IT-based support for network cooperation, in particular for innovation support, a relevant research aim. However, network research is inherently multi-disciplinary (Easley/Kleinberg, 2010). Furthermore, limited empirical work has been done on ecosystems (West/Wood, 2008).

3.4.5 Research Gap

The topics addressed in research relate to generic/conceptual aspects of service ecosystems are the actors and roles to be found in these networks, as well as business model and value network aspects. Research predominantly focuses on operational aspects: how can services be offered and delivered in a networked fashion considering strategic and technical aspects. Innovation processes are absent from current reasoning about service ecosystems which leads to a conceptual gap in current research. As services are jointly provided involving multiple actors it would be a logical step to also develop these services together. Joint innovation activities could leverage economic network effects, e.g., re-using existing services or components offered by other providers to shorten time-to-market and development costs. As argued by Riedl et al. (2009a) service ecosystems offer great potential to leverage the capabilities of actors, not only for joint service delivery, but also joint innovation and NSD. The following box summaries the research gap and points to a potential contribution to the knowledge base in the field of service ecosystems of this research:

Research Gap - Contribution of this Work to Field of Service Ecosystems
There is a conceptual gap in current service ecosystem research neglecting innovation aspects. This research extends our understanding of service ecosystem with innovation aspects which are currently ignored in the literature.

3.4.6 Criteria for a Solution

The presumptions from the subject domain of service ecosystems and the resulting networked organisations are summarised as two criteria for a solution below. Furthermore, the consolidated findings from established research on networked organisations have been integrated.

Our economy is increasingly driven by globalisation and organisational structures that span national and geographic boundaries. This general trend is amplified by the opportunities offered by electronic services. This research argues that a networked innovation paradigm rather than a closed innovation paradigm is necessary for successful innovation development within service ecosystems. This is due to their heavy reliance on re-use, their reliance on new business models, and knowledge leveraging as services are implemented as software (Gassmann, 2006; Spohrer/Kwan, 2009). As services are provided through a value network spanning different organisations, this degree of integration would also be necessary during the development of the service. To support such a networked innovation process in service ecosystems it would be necessary to provide a central, shared innovation repository through which the actors of the value network can interact and exchange information to jointly develop new services (Riedl et al., 2009a).

Criterion 3: Provide a shared innovation space through which the different actors can interact and exchange information.

The increasing informatisation and knowledge-intensity of all kinds of products and processes means that virtually no company is able to develop and own all knowledge required for designing, marketing, and providing its products or services (Ciborra, 1992; Ireland/Hitt/Vaidyanath, 2002; Prahalad/Hamel, 1990). As a consequence, and further fuelled by the opportunities offered by electronic services, companies are increasingly teaming up with external partners for organising innovation and knowledge creation processes (Powell, 1987). As argued by Riedl et al. (2009a), to harness service ecosystem's capabilities to innovate it is necessary to integrate all ecosystem actors and provide support for their diverse types of contributions to the central innovation space (e.g., feedback, service ideas, requirements, actual service implementations). This is consistent with the finding of new service development research that interactions are critical and that the incorporation of disparate perspectives increases creative potential (Syson/Perks, 2004; cf. Section 3.3).

Criterion 4: Support the integration of different actors with support for different tasks and different capabilities.

3.5 Open Innovation

How can innovations be developed in open, networked, and dynamic systems and markets such as those most electronic services are found in? Outside the core area of new service development a new research stream called *open innovation* is making progress (Chesbrough, 2003). Open innovation proposes principles for the design of innovation systems in which innovation processes are open for external collaboration with a network of customers, suppliers, and other partners (Ebner/Leimeister/Krcmar, 2009; Leimeister et al., 2009; Krcmar, 2009; Lichtenthaler/Lichtenthaler, 2009). It has been shown that implementing these principles increases innovation performance (Gassmann, 2006).

The tools and methods proposed by open innovation address the problems that are encountered when developing electronic services (e.g., rapid development; cf. Section 3.2.3) and can also help to exploit the new opportunities (e.g., the combination of existing services to form new service offerings, cf. Section 3.2.2; or the transparent feedback, cf. Section 3.2.4). Notably, the environment offered by service ecosystems provides a fertile ground for open innovation in which service ecosystems act as catalysts. The interorganisational networks that are formed by service ecosystem have many links with the idea of open innovation (cf. Vanhaverbeke/Cloodt, 2006). Consequently, e-services are particularly suited for development through open innovation and service ecosystems provide a promising environment for the implementation of these principles and thus to maximise the benefit derived from open innovation.

Open innovation describes an innovation process as an open, multi-layered search and solution process that is executed between several actors across organisational boundaries (Reichwald/Piller, 2009). As such, it offers an innovation approach to the open and networked environment found in service ecosystems. In the twentieth century, many leading companies generated and commercialised ideas for innovations in self-reliance, mainly through in-house R&D laboratories. Today, companies are increasingly rethinking the fundamental ways of managing their innovation activities. Overcoming companies' boundaries in order to open up to other sources of innovation has become increasingly important. In this context, customers are seen as one of the biggest resources for innovations (Chesbrough, 2006a; Chesbrough/Crowther, 2006; von Hippel, 1988; von Hippel, 2005; Enkel/Perez-Freije/Gassmann, 2005; Kristensson/Magnusson/Matthing, 2002). Open innovation research has its roots in open source software research (e.g., Henkel, 2006) and is a phenomenon of increasing importance to both theory and practice (Chesbrough, 2003).

A company's innovation process is commonly depicted as a funnel where many ideas enter, but only a few of them will be realised as new products or services because not all ideas are good ones and are discarded during an evaluation process. Furthermore, resource constraints might prevent ideas from being implemented. Open innovation proposes to open up companies' boundaries for ideas to enter the innovation funnel from outside (Figure 3.8). The main effect of including external information is to enlarge the base of information that can be utilised for the innovation process and thus to increase knowledge inflows for the focal firm (Chesbrough, 2006b; Piller/Ihl, 2009). The company, therefore, gains more ideas for innovations. At the same time, open innovation proposes to commercialise innovations outside the current market to maximise economic returns.

Open innovation is commonly seen in contrast to *closed innovation* (Chesbrough, 2006b). Closed innovation refers to an innovation model where a company develops, evaluates, tests, and commercialises only internal innovations using only internal resources and employees. External actors have no influence on the innovation process. Table 3.9 contrasts closed and open innovation.

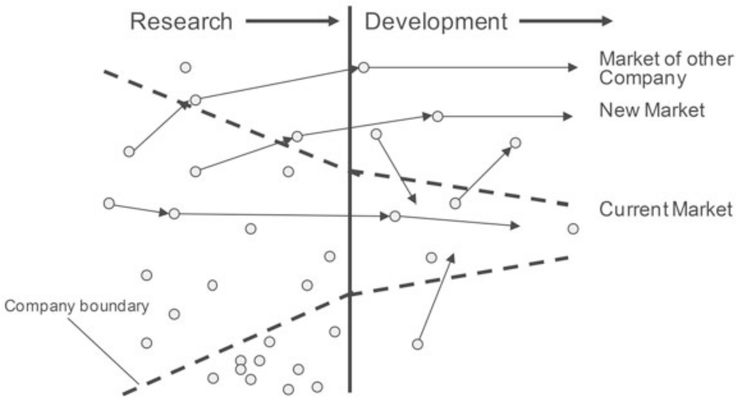

Figure 3.8: *Open innovation (adapted from Chesbrough, 2006b).*

Closed Innovation Principles	*Open Innovation Principles*
The smart people in our field work for us.	Not all the smart people work for us. We need to work with smart people inside *and* outside our company.
To profit from R&D, we must discover it, develop it, and ship it ourselves.	External R&D can create significant value; internal R&D is needed to claim some portion of that value.
If we discover it ourselves, we will get it to market first.	We don't have to originate the research to profit from it.
The company that gets an innovation to market first will win.	Building a better business model is better than getting to market first.
If we create the most and the best ideas in the industry, we will win.	If we make the best use of internal and external ideas, we will win.
We should control our intellectual property, so that our competitors don't profit from our ideas.	We should profit from others' use of our intellectual property, and we should buy others' intellectual property whenever it advances our own business model.

Table 3.9: *Contrasting principles of closed and open innovation (Chesbrough, 2006b, xxvi).*

3.5.1 Three Core Process Archetypes of Open Innovation

The opening of innovation and development activities to externals is driven by global trends of 1. globalisation of innovation, 2. outsourcing of R&D, 3. early supplier integration, 4. user innovation, and 5. external commercialisation of innovations (Gassmann, 2006). These open innovation processes lead to interfirm cooperation and development of ecosystems of networked firms sharing technology and trading intellectual property (West/Vanhaverbeke/Chesbrough, 2006).

Developments in the field of open innovation are varied and overlapping (West/Bogers, 2010). The theoretical developments in the field of open innovation can be categorised in many ways such as schools of thought (Gassmann, 2006), actors (Sawhney/Prandelli/Verona, 2003), or processes (Chesbrough/Vanhaverbeke/West, 2006; Gassmann/Enkel, 2004; Prahalad/Ramaswamy, 2004). The process perspective seems particularly suitable for this introduction as it allows explaining their relevance in practice through illustrative figures (Enkel/Gassmann/Chesbrough, 2009). Three core processes archetypes can be differentiated in open innovation: the outside-in process, the inside-out process, and the coupled process (West/Gallagher, 2006; Enkel/Gassmann/Chesbrough, 2009; Dahlander/Gann, 2010). The following sections analyse the three process archetypes in more detail. The actors' perspective will be analysed in more detail in Section 5.1.

3.5.1.1 Outside-In Process

The outside-in process enriches a company's knowledge and innovation base through the integration of suppliers, customers, and external knowledge sourcing (Enkel/Gassmann/Chesbrough, 2009). This process has been found to increase a company's innovativeness (Laursen/Salter, 2006; Lettl/Herstatt/Gemuenden, 2006; Piller/Walcher, 2006). One reason is the increased diversity of people working at the creative problem solving (Terwiesch/Xu, 2008). This process reflects companies experience that in order to develop an innovation, they do not necessarily have to create the knowledge themselves (Teece, 1986). A study by Enkel/Gassmann (2008) of 144 companies revealed that knowledge sources are mostly clients (78%), suppliers (61%), competitors (49%), as well as public and commercial research institutions (21%). Furthermore, a large body of other sources was used (65%), including non-customers, non-suppliers, and partners from other industries. Companies increasingly rely on their customer base for product and service innovation. The benefits of customer integration, user driven innovation, and open innovation are well recognised and established in research (e.g., von Hippel, 2005; Ogawa/Piller, 2006; West/Lakhani, 2008; Surowiecki, 2005; Chesbrough, 2006b).

Other approaches within the outside-in process, can be seen in an increasing awareness of the importance of innovation networks (Dittrich/Duysters, 2007; Chesbrough/Prencipe, 2008), new forms of customer integration, such as crowdsourcing (Surowiecki, 2005; Howe, 2008), innovation competitions (Ebner, 2008; Ebner/Leimeister/Krcmar, 2009; Leimeister et al., 2009; Bretschneider, 2010), mass customisation (Piller, 2006), and customer community integration (West/Lakhani, 2008; Di Gangi/Wasko, 2009), as well as the use of innovation intermediaries, such as InnoCentive,[3] NineSigma,[4] or yet2.com[5] (Nambisan/Sawhney, 2007; Lakhani/Panetta, 2007; Nambisan/Sawhney, 2008).

Specifically in the area of new service development customer involvement has a positive impact on market performance by improving technical quality and speed of development, which is particularly important for e-services (Carbonell/Rodríguez-Escudero/Pujari, 2009). Furthermore, the positive effects of customer's involvement are particularly strong in highly innovative technologies and independent of the innovation phase in which customers are engaged (Carbonell/Rodríguez-Escudero/Pujari, 2009).

3.5.1.2 Inside-Out Process

The inside-out process refers to earning profits by bringing ideas to market, selling intellectual property (IP), and multiplying technology by transferring ideas to the outside environment (Enkel/Gassmann/Chesbrough, 2009). The focus of companies establishing the inside-out process as key, is on externalising their knowledge and innovation in order to bring ideas to market faster than they could through internal development. Innovations are exploited outside the company's boundaries by generating profits through licensing IP and multiplying technology by transferring ideas to other companies (Enkel/Gassmann/Chesbrough, 2009). The main point is being no longer restricted by the markets the firm currently serves but instead participating in other segments using licensing fees, joint ventures, or spin-offs. The inside-out process thus exploits a company's unused inventions in different markets and a managed trade of intellectual property. These different streams of income create more overall revenue from the innovation (Gassmann/Enkel, 2004; Lichtenthaler, 2009).

3.5.1.3 Coupled Process

The coupled process refers to co-creation with complementary partners through cooperation, alliances, and joint ventures during which give-and-take are crucial for success (Enkel/Gassmann/Chesbrough, 2009). The coupled process combines the outside-in process (to gain external knowledge) and the inside-out processes (to bring ideas to market) in a third open innovation process archetype allowing companies to jointly develop and commercialise innovation.

Co-creation is a widely studied topic in the open innovation management literature (Enkel/Gassmann/Chesbrough, 2009). Derived from open source project development (von Hippel/von Krogh, 2006), open innovation research strongly focuses on peer-production through

- communities (Lakhani/Wolf, 2005; Lakhani/Panetta, 2007; Fleming/Waguespack, 2007; West/O'Mahony, 2008; Leimeister et al., 2009; Reichwald/Piller, 2009;

[3] http://www.innocentive.com/ (last accessed 2010-10-26)
[4] http://www.ninesigma.com/ (last accessed 2010-10-26)
[5] http://www.yet2.com/ (last accessed 2010-10-26)

Bullinger/Haller/Möslein, 2009),
- consumers (Hienerth, 2006; Lettl/Herstatt/Gemuenden, 2006),
- lead users (von Hippel, 1988; von Hippel, 2005; Franke/von Hippel/Schreier, 2006), e.g., through toolkits (von Hippel/Katz, 2002),
- universities or research organisations (Perkmann/Walsh, 2007; Asakawa/Nakamura/Sawada, 2010), and
- partners from other industries (Enkel/Gassmann, 2010).

3.5.2 Critical Reflection

The following paragraphs summarise open innovation research by examining in closer details potential advantages and disadvantages.

Advantages The benefits of customer integration, user driven innovation, and open innovation are well recognised and established in research (e.g., von Hippel, 2005; Ogawa/Piller, 2006; Lakhani/Panetta, 2007; West/Lakhani, 2008; Surowiecki, 2005; Chesbrough, 2006b; Gassmann, 2006; Dodgson/Gann/Salter, 2006). Some of the most lucrative and novel innovations have been developed by users attempting to adapt existing products and processes to better suit their own needs (Lüthje/Herstatt/von Hippel, 2005; Morrison/Roberts/von Hippel, 2000). The successful impact of open innovation strategies has been described in several publications (see Gassmann (2006) for an overview). Firms that are too internally focused may miss opportunities for innovation, as many knowledge sources necessary can only be found outside the firm (Laursen/Salter, 2006). In addition to enabling innovation by pointing to new opportunities, the integration of externals also has a positive influence on speed of development which is especially important for the development of e-services (Carbonell/Rodríguez-Escudero/Pujari, 2009). As a result, integration of externals in R&D projects is higher in the “fast clockspeed” category than in the “slow clockspeed” category (Enkel/Gassmann/Chesbrough, 2009). A study investigating SMEs found open innovation to have positive effects on the speed of development, provide access to complementary assets, and reinforce strength by concentrating on core capabilities (Lee et al., 2010).

The ability to interact with other people has been found to have a positive effect on the number of high-quality innovation ideas created by individuals (Björk/Magnusson, 2009). Consequently, the possibility to interact with other people should be supported and facilitated. Due to the high-degree of customer involvement in service delivery, customer integration has a long tradition in NSD (e.g., van der Aa/Elfring, 2002; Gallouj/Weinstein, 1997), even before the popular introduction of open innovation. However, the concepts proposed by open innovation research provide a much needed systematisation of approaches for customer integration and co-creation that can complement NSD research.

Disadvantages When aiming at integrating customers into a company’s innovation process, a key concern becomes how customers can be motivated to contribute ideas. Bretschneider (2010) investigated which motives make customers participate in ideas communities and which innovation relevant personality traits they have. The scope of this research are the aspects of implementing and supporting open innovation process on a technical level by providing tool support. To address the motivational aspects of customer participation in innovation communities, the results by Bretschneider (2010) can be consulted.

Besides motivational aspects, issues related to intellectual property rights emerge once external participants are integrated into a firm's innovation process. IP related issues emerge from the tension between value creation and value capture, a key concern of open innovation (Simcoe, 2006). Chesbrough (2006b) argues that a company can rarely control an important technology for an extended period of time. Companies must increase the "metabolic rate" at which they access, digest, and utilise knowledge in a world where knowledge is rapidly diffused and imitated. Consequently, the wiser course of action is to treat a firm's knowledge as fundamentally dynamic, rather than static, and actively plan the exploitation of ideas. As a result, a firm following the open innovation paradigm manages IP not only to leverage its own business, but also to profit from others' use of the firm's ideas (Chesbrough, 2006b). This idea is also reflected in the general approach of service ecosystems in which actors come together in order to leverage on each others capabilities. Particularly in highly networked environments where interorganisational innovation collaboration has been firmly established firms that do not participate in innovation collaboration can suffer serious competitive disadvantages. Firms which do not cooperate and do not exchange knowledge suffer a risk of selective knowledge use and reduce their knowledge base on a long-term basis (Koschatzky, 2001).

IP issues have also been analysed regarding the integration of customers into a firm's innovation process under the term "freely revealing." When an innovator freely reveals information about a product or service he/she has developed, all intellectual property rights to that information are voluntarily given up by the innovator. All interested parties gain access to the information and it becomes a public good (von Hippel, 2005). Contrary to the economic assumption that if a user's innovation has value to others the user would strive to prevent free diffusion, empirical research has shown that individual users, user firms, and even manufacturers often freely reveal detailed information about their innovations (Harhoff/Henkel/von Hippel, 2003; von Hippel, 2005; Henkel, 2006; von Hippel/von Krogh, 2006). Reasons for free revealing include 1. users think others already know similar things, 2. profits from patenting are low, 3. incentives for free revealing are positive (e.g., gains through indirect network effects), 4. build human and social capital (e.g., gains in reputation), 5. setting of a "dominant design" or even an "open standard", and 6. lack the means to exploit their innovation by selling it (von Hippel/von Krogh, 2006; Henkel, 2006; Simcoe, 2006; Fleming/Waguespack, 2007).

The interorganisational networks that are formed by service ecosystem have many links with the idea of open innovation (cf. Vanhaverbeke/Cloodt, 2006). Furthermore, NSD in the context of service ecosystems is bound to involve many actors (Section 3.4). The reverse cost structure and fast cycle times make e-services particularly suitable for participatory development and customer co-creation. Consequently, this research argues that an open, rather than a closed innovation approach is necessary for service ecosystems.

3.5.3 Research Gap

Open innovation can be studied on different levels for different units of analysis. Common levels are to study open innovation on the individual, organisational, dyadic, inter-organisational, and national or regional innovation system level (Vanhaverbeke/Cloodt, 2006). As Vanhaverbeke (2006) argues that in order to understand open innovation correctly it has to be analysed on complementary levels, two of which are the network and the firm level. Until today most research has focused on studying open innovation on the firm level (West/Vanhaverbeke/Chesbrough, 2006). The value networks formed by service ecosystems and the innovation networks formed by open innovation share similar aspects. Value networks and ecosystems have been recognised as an important part of cooperation in open innovation (West/Wood, 2008; Chesbrough, 2003; Maula et al., 2006; Vanhaverbeke/Cloodt, 2006). However, these aspects have not been studied in details due to the prevalent focus of studying open innovation on the firm level. Consequently, studying open innovation on a network level is a research gap that requires additional investigation. In general, network thinking is not only important for studying innovation and value networks in service ecosystems but will become essential to all branches of science (Strogatz, 2001).

The implications and trends that underpin open innovation are actively discussed in research from a variety of different directions. Implications are discussed in strategic, organisational, behavioural, knowledge, legal and business perspectives, and its economic terms (Enkel/Gassmann/Chesbrough, 2009). This research approaches open innovation from an organisational, in particular network oriented, approach by combining it with the field of service ecosystem (who are the actors involved and how can they contribute to the innovation process?) as well as from a technical perspective (what IT support is necessary to successfully implement an open innovation approach for a network of actors to jointly develop new e-services?).

Research Gap - Contribution of this Work to Field of Open Innovation
This work contributes to open innovation research by extending the focus from that of a single firm prevalent in current research to that of a network of actors bound together through a central platform.

3.5.4 Criteria for a Solution

The presumptions in form of a developed research gap and the characteristic attributes of networked innovation and co-creation are summarised as criteria for a solution to provide tool-supported innovation management for the systematic development of electronic services. Furthermore, the consolidated findings from established open innovation research have been integrated.

Companies increasingly rely on their customer base for product and service innovation. The benefits of customer integration, user driven innovation, and open innovation are well recognised and established in research (e.g., von Hippel, 2005; Ogawa/Piller, 2006; Lakhani/Panetta, 2007; West/Lakhani, 2008; Surowiecki, 2005; Chesbrough, 2006b). Additionally, the reverse cost structure of electronic services makes them particularly susceptive to participatory development as the majority of costs accrue during the development and not during production.

Due to the diverse nature of the different innovation and usage phases it is unlikely that all these diverse functions can be provided by a single tool. In particular the integration of service feedback (cf. criterion 1 to support the full service life-cycle) would require the integration of service evaluation mechanisms provided by the service runtime environment. Furthermore, the different methods for open innovation like communities, lead user method, toolkits for innovation, idea competitions require specialised tool support. To prevent ideas from residing in silos, the different tools need to be integrated. To provide support for truly open innovation processes, it is necessary to integrate the contributions of the various actors into a single innovation space. It is necessary, for example, to integrate the results of a lead user workshop with the developments of internal R&D, and further with user feedback received once a service has been launched. A central aim of open innovation is to overcome silos by promoting a more open exchange of innovation activities. If, however, an organisation or network of organisations is not able to integrate the inputs it receives from different open innovation initiatives, new silos emerge. Consequently, the innovation system has to be open-ended and allow the integration of various special-purpose tools that are necessary to support the individual requirements of the full service life-cycle.

Criterion 5: Ability to integrate various special-purpose tools for individual phases and tasks.

Offering an open and extensible platform explicitly anchors the business model within the open innovation paradigm. Open innovation processes involve building long-lasting network relationships with customers, suppliers, research institutions, and other external partners. These network relationships are equally important for inside-out as well as for outside-in processes. Consequently, innovation has to be managed as a continuous process. Service innovations are often of an incremental nature (de Brentani, 2001). Furthermore, through the electronic nature of services in service ecosystems continuous improvement and refinement of services is one of the key advantages. This results, however, in the concurrent development of several service innovations that are in different stages of the innovation process. Especially this complex and intermingled process of concurrently developing a set of ideas would require adequate IT support.

Criterion 6: Ability to simultaneously cope with ideas at different stages of the innovation process.

3.6 Summary

This chapter first offered relevant service terminology and a working definition of a service as a *business activity of value exchange that is accessible through an electronic interface.* The chapter then developed five areas of key difference between electronic and non-electronic services: 1. the cost structure of services, 2. the high degree of outsourcing, 3. the rapid development of new services, 4. the availability of transparent service feedback, and 5. the continuous improvement of services. Using the five key areas of difference a systematic review of NSD literature showed that current NSD methods are ill equipped to address the constraints and opportunities of electronic services. The review of the service ecosystem domain provided an introduction to networked organisations and highlighted the conceptual gap in service ecosystem research where innovation aspects are currently ignored. The next section first motivated the use of open innovation as an approach for innovation in service ecosystems due to its focus on interorganisational innovation and collaboration. Then, the concept of open innovation has been introduced in more detail, elaborating in particular the three process archetypes of outside-in, inside-out, and coupled processes.

We argue that the open innovation paradigm rather than the closed innovation paradigm is necessary for successful development of electronic services. This is due to their heavy reliance on re-use, their reliance on new business models, and knowledge leveraging as services are implemented as software (Gassmann, 2006). As open innovation is geared towards systematically integrating external ideas and influences into the internal innovation process, a systematic approach becomes available for the integration of the transparent feedback generated by service usage of electronic services. To support such an open innovation process in the networked environment in which electronic services operate in, it is necessary to provide a central, shared innovation repository through which the diverse actors like service provider, customer, and aggregator can interact. Thus, a duality of an open and networked structure for the delivery of many electronic services and an open and networked model for the development of these services is created. Taken together the special requirements posed by developing new electronic services, the environment of highly networked services, and the move to an open innovation model offer the potential for new and improved service innovation approaches that are until now little understood.

This chapter serves three purposes: 1. it provides the conceptual foundations of this research, 2. it identifies research gaps and frames the contribution of this work, and 3. it provides a set of criteria to guide the design of tool-supported innovation management in service ecosystems. The criteria also serve to answer research question one from Section 1.2.

Conceptual Foundations The aim of this research is to provide tool support to develop new electronic services in the context of service ecosystems using the methods proposed by open innovation. As such, it is necessary to base the work at the intersection of the three areas NSD, service ecosystems, and open innovation. This chapter provides the conceptual foundations and groundwork necessary to develop the research. It serves as an introduction to the problem domain of developing new electronic services in the context of service ecosystems.

Research Gap and Contribution The chapter analyses prior research to identify research gaps to support the argument that currently known solutions cannot sufficiently solve the problem of developing electronic services in the context of service ecosystems. Furthermore, the clear development of the research gaps shows how this research contributes to the three identified areas by extending and contributing to important issues that are until now not sufficiently addressed: 1. the deficiencies of NSD methods to address the unique requirements and opportunities of developing electronic services; 2. the lack of an innovation perspective in the current reasoning about service ecosystems; and 3. the predominant focus on individual organisations as the level of analysis in open innovation research. In short, the literature review presented in this chapter not only discusses what has been done and why but it also points out the areas in which this work has implications.

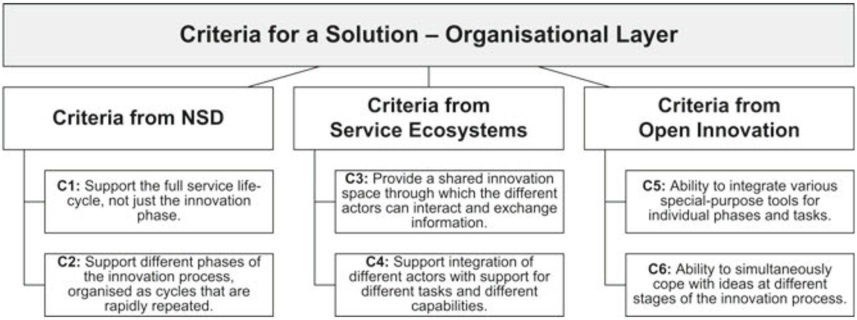

Figure 3.9: *Summary of criteria for tool-supported innovation management in service ecosystems on an organisational layer.*

Criteria for a Solution For each of the three areas, we proposed two criteria that a solution for tool-supported innovation management should address. The criteria can be classified on an organisational layer, as opposed to a theoretical one. They address the first research question asking what key requirements are necessary to provide tool support. Furthermore, the criteria will be used to evaluate the robustness of the solution in Chapter 7. The criteria and the domain they originate from are summarised in Figure 3.9.

This chapter argued that understanding of the three research areas NSD, service ecosystems, and open innovation is a necessary foundation for this research. NSD serves as the basis because it provides a complete method for the development of new services, service ecosystems because it is the intended application domain, addresses the networked nature of e-services, and presents a model to understand the different actors found in service ecosystems, and open innovation as an approach to managing not only the networked service delivery found in service ecosystems but also networked innovation and customer integration. While this chapter laid out the conceptual foundations of the research and offered criteria for a solution on an organisational layer, the next chapter introduces the central theoretical foundations of this research and offers a solution criterion on a theoretical layer.

Chapter 4

Theoretical Foundation

Information systems research has been long concerned with improving task-related performance. For that purpose the concept of fit is often used to explain how a system's design can improve performance and overall value. Examples are the theories of *cognitive fit* (Vessey/Galletta, 1991) or *task/technology fit* (Zigurs/Buckland, 1998). These theories argue that fitting a computer system to a user and the task a user tries to perform using the computer system enhances the desired outcome and has a positive effect on overall performance (Vessey/Galletta, 1991; Goodhue/Thompson, 1995; Zigurs/Buckland, 1998). Until now, research has mainly focused on performance evaluation criteria that are based on measures of task efficiency, accuracy, or productivity (Zhang/Li, 2004). As argued by Avital/Te'eni (2009) this view was sufficient in the early days of personal computing when computers were seen mainly as productivity tools. Nowadays, productivity gain is no longer the single most important evaluation criterion. Today user's expectations of computer systems have dramatically changed. In many instances, computer systems are expected to be intelligent, communicative, and stimulating in order to enhance our creativity, reveal opportunities, and support innovation (Abraham/Boone, 1994; Shneiderman, 2002). Particularly in the area of tool-supported innovation management these stimulating aspects are important rather than pure task-oriented performance.

To address this challenge Avital/Te'eni (2009) propose the concept of *generativity* and develop two corresponding design considerations: *generative capacity* and *generative fit*. *Generative capacity* is an attribute of a person, which refers to ones ability to reframe reality and subsequently to produce something ingenious or at least new in a particular context. *Generative fit* on the other hand is an attribute of a system, which refers to the extent in which a particular information technology artefact, or part thereof, is conducive to evoking and enhancing that generative capacity in people. They submit that systems with high generative fit will help people to realise their generative capacity. They propose operationalisations of the two interrelated concepts that can guide systems designers who aim to enhance creative work, unstructured syntheses, and serendipitous discoveries (in parts published earlier in Avital, 2007).

These two design considerations and their resulting operationalisations serve as the overarching theoretical basis of this work. This chapter reviews the theory of generative capacity and related theoretical foundations. The review focuses on the more technical aspects and, in particular, the system design consideration. Based on the theory foundations laid out

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here, Chapter 5 will introduce an integrated system design for tool-supported innovation management in service ecosystems.

4.1 Concepts of Generativity

Generativity is generally defined as an ability or capacity to generate or produce something (Merriam-Webster). As Weick (2007) puts it, it refers to an evocative power or aptitude that can result in producing or creating something. This is congruent with our natural language understanding of the term where "to generate" means to bring into existence. The Oxford dictionary defines "to generate" as "1 cause to arise or come about. 2 produce (energy, especially electricity)" (Oxford Dictionaries, 2010). Generativity stresses a productive capacity that focuses on creating something, abstract or concrete, that is desirable and beneficial. Thus, the generative activity is "a source of innovation, of productive change as when a team invents new ways of working more effectively" (Cook/ Brown, 1999, 393). The concept of generativity has been applied in various fields of social science. Table 4.1 provides an overview of the concept in different fields. In summary, Avital/Te'eni (2009, 349) define *generativity* as

> "a capacity for rejuvenation, a capacity to produce infinite possibilities or configurations, a capacity to challenge the status quo and think out-of-the-box, a capacity to reconstruct social reality and consequent action and a capacity to revitalize our epistemic stance."

In the context of human-computer interaction and systems design, and building on the conceptualisations of generativity summarised in Table 4.1, Avital/Te'eni (2009, 349) submit that

> "*generative capacity* comprises the ability to rejuvenate, to produce new configurations and possibilities, to reframe the way we see and understand the world and to challenge the normative status quo in a particular task-driven context."

4.2 Theory of Generative Fit

The term *generative fit* is used to denote the extent to which an information technology-based system is designed to complement, bolster, and enhance the inherent generative capacity of its users as introduced above (Avital/Te'eni, 2009). The idea of "fit" plays a central role in theories that focus on the interaction between humans and computers. The generic concept of fit maintains that matching (i.e., fitting) the human-computer interface to the attributes of a user and an underlying task enhances performance (Vessey/ Galletta, 1991). As argued above, task performance, the outcome of good fit, has been conceptualised and operationalised in the literature mainly with efficiency-based criteria related to the task at hand (e.g., measures of task efficiency, accuracy, or productivity).

Discipline	*Theory*	*Generative Facet*
Psychology (Erik Erikson)	Psychosocial generativity	The drive to rejuvenate; to reproduce; to nurture and guide the next generation.
Linguistics (Noam Chomsky)	Generative grammar	A finite set of rules that generates infinite syntactical configurations.
Organisation science (Donald Schön)	Generative metaphor	Figurative descriptions of social events that shape the attitudes and behaviours toward them.
Social psychology (Kenneth Gergen)	Generative capacity	The ability to challenge the status quo and to transform social reality and social action.
Architecture (Christopher Alexander)	Generative schemes	A simple recipe that allows creating a well-built artefact that is adjusted to its unique context.
Computer science (John Frazer)	Generative evolutionary design	Generating multiple disparate sets of design alternatives that may be inspiring to designers.
Social studies (Danielle Zandee)	Generative inquiry	A recurring hermeneutic process that generates theoretical quantum leaps.

Table 4.1: *Formative theories that apply the generativity concept in various disciplines (adapted from Avital/Te'eni, 2009).*

Task-related performance has two unique components: one component of performance is *operational efficiency*, and the other is *generative capacity* (Avital/Te'eni, 2009). Table 4.2 juxtaposes different dimensions of the two components. Operational efficiency refers to the type of task performance usually studied in fit-related literature. It relates to tasks with low ambiguity, finite in nature, with restricted outcomes and in which the user is expected to be efficient, accurate, and on time. Generative capacity, on the other hand, relates to a user's ability to deal with unclear tasks with high ambiguity, open-ended in nature, and in which the user is expected to be innovative and expansive.

Whereas for some kind of tasks operational efficiency is critical and generative capacity is undesired or even counterproductive, for other tasks operational efficiency is not relevant and generative capacity is critical. Other than in some extreme cases, however, most tasks require a carefully elaborated blend of both operational efficiency and generative capacity (Avital/Te'eni, 2009).

These two instances are also found in Guilford's (1967) schema of convergent thinking and divergent thinking. The same concept is also found by van Gundy (1988). The distinction between divergent and convergent thinking serve as the fundamental typology of a human approach to problem solving. Convergent thinking refers to an analytic mode focusing on deductive generation of a single optimal solution to a given problem. Divergent thinking, on the other hand, refers to a fluid synthetic mode focusing on creative generation of multiple disparate answers to a given problem (Guilford, 1967; van Gundy, 1988). This distinction is widely used to structure the design of computer systems (e.g., Nunamaker et al., 1996; Fjermestad/Hiltz, 2001; Briggs/de Vreede/Nunamaker, 2003).

Dimension	*Operational Efficiency*	*Generative Capacity*
Cognitive process	Convergent	Divergent
Nature of task	Low ambiguity	High ambiguity
Boundary of task	Restricted	Open-ended
Nature of outcome	Known in advance	Unknown, at least in part
Desired Action/process	Follow procedure	Be creative, innovate
Orientation of outcome	Close gaps	Open gaps
Success criterion	Efficiency, accuracy, punctuality	Making a difference, rejuvenating

Table 4.2: *Juxtaposing two task-related performance types (adapted from Avital/Te'eni, 2009).*

Convergent thinking represents a fundamental need for convergent action that requires users to be concrete, accurate, effective, fast, and with little or no deviation from standard operating procedures. Divergent thinking represents a fundamental case of diverging action that requires users to be imaginative, creative, innovative, provocative, and with little or no conformism (Avital/Te'eni, 2009). Figure 4.1 provides a graphical illustration of this fundamental distinction in thinking concepts.

The extent of each component, i.e., the extent of desired operational efficiency and generative capacity, differs according to the characteristics of the underlying task. In extreme instances, only one component is desirable and the other is not relevant (points 1 and 5 in Figure 4.1). Point 1 presents a task where only divergent thinking is required such as in a scenario planning where the aim is to explore as many scenarios as possible. Point 5 presents a task where only operational efficiency is required (and desired) such as in a manufacturing control system. In most cases, however, the underlying task requires a *blend* of both operational efficiency and generative capacity (Avital/Te'eni, 2009). Point 3 represents cases in which *both* operational efficiency and generative capacity are equally critical for performance. For example, tasks related to computer-assisted design of a building. In the same fashion, point 2 represents cases in which the blend should emphasise generative capacity (e.g., tasks related to decision support systems (DSS) or executive support systems (ESS)). Point 4, on the other hand, represents cases in which the blend should emphasise operational efficiency (e.g., tasks related to a keyword search as in the case of a reference search in online publication databases). In applications requiring both the "main concern [..] is fine-tuning the blend of operational efficiency and generative capacity for the particular task characteristics" (Avital/Te'eni, 2009, 352). In complex systems the required blend needs to be assessed for the right balance on a case-by-case basis.

Consequently, *generative fit* is defined as

> "the extent to which the functionality and process support of a (computer) system are designed to complement and enhance ones innate generative capacity in a particular task-driven context. Therefore, generative fit enhances the human resources needed in the production of new, ingenious, task-driven output configurations" (Avital/Te'eni, 2009, 352).

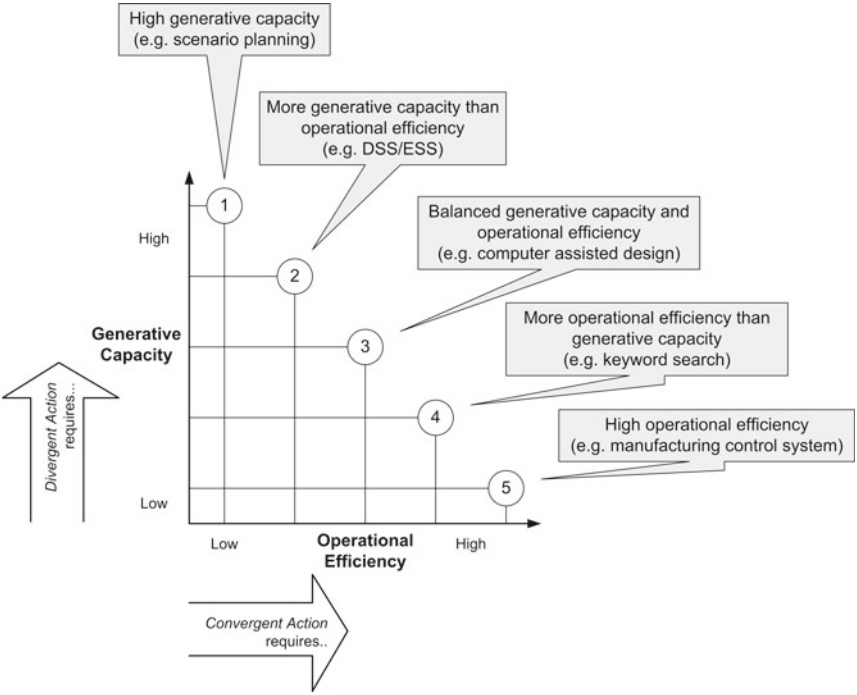

Figure 4.1: *Balancing between the need for operational efficiency and generative capacity based on task characteristics (adapted from Avital/Te'eni, 2009).*

The concept of *generative capacity* is an attribute of a person which refers to ones ability to reframe reality and subsequently to produce something ingenious or while *generative fit* is an attribute of a system which refers to the extent in which a particular information technology artefact is conducive to evoking and enhancing that generative capacity in people.

4.3 Creativity and Generative Capacity

Although generative capacity and creativity are associated with innovation, the two concepts are different in nature. Avital/Te'eni (2009) argue that generative capacity and generative fit provide superior foundations for designing systems that are conducive to innovative work over concepts related to creativity. This section reviews literature related to creativity to broaden the point of departure and discusses the relationship between creativity and generative capacity.

Creativity has been defined, for example, by Rickards (1974, 13f) as a process "which gives rise to novel combinations of concepts which have significance to the solver or his environment" or as an "escape from mental stuckness" (Rickards, 1988, 225). A similar definition can be found by DeGraff/Lawrence (2002, 4) who define creativity as "a purposeful activity (or set of activities) that produces valuable products, services, processes, or ideas that are better or new." As these definitions show, there is a broad range of views on creativity in the social and cognitive sciences and so far no clear holistic framework has emerged to unite them (Sternberg, 2006; Kaufman/Sternberg, 2006). However, it has been generally agreed that research on creativity can be classified into four main domains: 1. creativity as a human trait or dispositional characteristic of a *person*, 2. creative *environments* or climates; sometimes referred to as *press*, 3. creative *processes* and tools, and 4. creativity as a trait of outputs, or *product*, of all sorts and varying degrees of abstraction ranging from a concrete product to an idea (Brown, 1989). The term *4-Ps model* is sometimes used to refer to the four different domains of creativity: person, process, product, and press (Couger/Higgins/McIntyre, 1993). Each of these domains represents a different interpretation of the notion of creativity.

In the field of information systems, research on creativity usually falls into the following four areas (Avital/Te'eni, 2009):

- creativity during the system analysis, design, and development processes and creative attributes of information technology employees (e.g., Nambisan/Agarwal/Tanniru, 1999; Cooper, 2000);
- the effect of DSS and creativity support systems on creative decision-making of individuals (e.g., Elam/Mead, 1990; Abraham/Boone, 1994; Massetti, 1996);
- the effect of group support systems (GSS) and group decision support systems (GDSS) on creative problem solving in conventional groups (e.g., Dennis et al., 1996; Garfield et al., 2001; Hender et al., 2002); and
- the effect of computer-mediated collaborative technologies on the production of creative outputs by members of distributed groups or virtual teams (e.g., Boland Jr/Tenkasi/Te'eni, 1994; Ocker et al., 1995; Majchrzak et al., 2000; Malhotra et al., 2001).

Within these four areas of creativity research in information systems there are several problems. Despite the general agreement about the main building block of creativity as a phenomenon of study (i.e., person, environment, process/tools, and output), the exact relationships among them are not clearly established (Santanen/Briggs/de Vreede, 2002), let alone their relationships with other key constructs in information systems (Couger/Higgins/McIntyre, 1993). This can lead to misconceptions of fundamental relationships which in turn might lead to flaws in research design and ambiguous or invalid conclusions about creativity (Wierenga/Van Bruggen, 1998). The basic model assumes a creative person (or group) producing a creative output. In this model human traits are modelled as the antecedents (i.e., independent variables) of a creative output (i.e., dependent variables). The role of information technology in this basic relationship is the focal point of creativity research in the information systems field. However, without a clear overall understanding of the mechanics of creativity, the exact role of information technology in that context has been left ambiguous (Avital/Te'eni, 2009). In this context, information technology can be modelled as a *moderator* if it is seen as having an impact on a creative process of a person. It may be modelled as a *mediator* if it is seen as a medium that transforms and transmits the creative act of a person or a group to the output. In the case of artificial intelligence or smart agents, information technology can be also modelled as an *antecedent* or *source* of a creative output (Avital/Te'eni, 2009). Massetti (1996), on the other hand, introduces the availability of a creativity support system as a separate and additional independent factor. Thus, if one wants to determine the effect of this factor on creative output, it has to be established that this effect is not due to differences in creativity as a trait of a person between the respondents in the various experimental groups. Resulting from these difficulties in the conceptualisation of creativity in information systems research and a lack of a general theory of creativity, most studies focus on a partial subset of interest and "leave the rest in the shadow, subject to speculation or arbitrary assumptions" (Avital/Te'eni, 2009, 354).

A move from creativity to generative capacity represents a shift in focus. While discussion of creativity is geared toward the finite end-result, the discussion of generative capacity is geared towards the perpetual and vitalising sources of innovation (cf. Avital/Te'eni, 2009). While creativity research is geared towards the creative *output*, generative capacity is geared towards the ability of a person (or group) to produce something new, i.e., the underlying source or origin of innovation, the *root cause*. Thus, making the implicit explicit by directly examining generative capacity instead of various other alternative operationalisations, may help in reducing the complexity and ambiguity currently built into the concept of creativity and its measurement (Avital/Te'eni, 2009). In an analysis of online innovation communities, Di Gangi/Wasko (2009) demonstrate that successful implementation does not only depend on the creativity of an idea (i.e., the creative output) but also on the ability of a community to communicate and consolidate individual contributions (i.e., operational efficiency). Hence, generativity can be seen as a more suitable concept to direct tool development than pure creativity.

In summary, the concept of generative capacity and generative fit seems to be more suitable to guide the design of tool support for innovation management in service ecosystems than the concept of creativity. Based on the two concepts Avital/Te'eni (2009) propose several system design directives which will be discussed in the next section.

Generative Design Directive	*System Feature*	*Illustrative Contribution to Generative Fit*
System should be evocative	D1: Visualisation	Digital 3-D representations of building construction plans allow vivid views of any architectural or structural objects from any angle or point of view.
	D2: Simulation	Simulation of smoke spread in case of fire; simulation of snow accumulation on various roof shapes; simulation of temperature build up.
	D3: Abstraction	Zoom in/out from the widget level to complete building view.
	D4: Integration	Integrated Virtual Prototyping system allows overlay of cross-domain drawings with no regard to craftsmanship boundaries.
	D5: Communication	Support of cross-domain exchange and sharing; everybody has access to all drawings.
System should be adaptive	D6: Customisation	Customised interfaces for various work types, work environments and personal preferences.
	D7: Automation	System recalls last view; system provides selective set of screen tools.
System should be open-ended	D8: Peer-production	Extensible system partners in engineering companies can build their own extensions.
	D9: Rejuvenation	Open development standards; easy upgrade path.

Table 4.3: *Generative design directives and features with illustrative examples based on a 3-D CAD system (adapted from Avital/Te'eni, 2009).*

4.4 System Design Considerations

Avital/Te'eni (2009) offer three broad design directives for generative designs: they should be evocative, adaptive, and open-ended. For each of the three design directives they propose several operable features that contribute to generative fit, as summarised in Table 4.3. These design considerations will serve as guiding paradigm for the system design and prototype developed in this research. For that purpose, reference numbers (D1 through D9) have been added to the table and will be referred back to in Section 5.4 when presenting a system design for tool-supported innovation management in service ecosystems. Table 4.3 also offers an illustrative examples based on a 3-D CAD system. The following sections present the design directives in more details.

4.4.1 Generative Design is Evocative

Systems with high generative fit inspire users to create something unique. Thus, they evoke new thinking and help them translate their ideas into a new context. IT systems can help by creating an environment that allows juxtaposing diverse frames that are not commonly associated with each other (Sternberg, 2006; Santanen/Briggs/de Vreede, 2004). There are several ways how an information technology can achieve this:

Visualisation Systems should provide visualisation tools that enable users to explore data in multiple dimensions to make new discoveries. They should allow filtering the data appropriately and adjust the visualisation features in order to visualise characteristics of networks and hierarchies, to see relationships in general (Shneiderman, 2007). A visualisation provides the ability to see an object from *multiple perspectives* and thus to search for new insightful points of view.

Simulation Systems should incorporate simulation tools that enable testing the object of interest in *multiple situations*. This refers to the underlying behaviour, dynamic capabilities, or response to particular influences from the environment in different contexts.

Abstraction Systems should incorporate abstraction tools that enable examining objects at *multiple degrees of granularity*. Systems should allow users to swiftly move between levels of granularity thus gaining an overview but also detailed information when needed. Moving between levels of granularity gives users the ability to identify emergent patterns, commonalities, and anomalies (Srinivasan/Te'eni, 1995).

Integration Systems should incorporate integration tools that enable aligning related domains, objects, or processes in *multiple overlay configurations*. The integration aspect refers to the ability to mix additional tools, functions, and subsystems. The integrated tools may possibly originate from related domains which allow overlaying or merging views or objects from different disciplines, practices, or organisations. Such an integrated platform can promote system-wide boundary crossing and cross-fertilisation (Boland Jr/Tenkasi/Te'eni, 1994).

Communication Systems should incorporate communication tools that enable sharing of *multiple points of view*. Systems should allow users to share information with other actors with no regard for spatial or temporal collocation. Communication tools thus enable cross-fertilisation though information sharing, ad hoc and ongoing cooperation, and collaborative work practices.

4.4.2 Generative Design is Adaptive

Systems with a high generative fit can be used by diverse sets of people, in diverse environments, and for various tasks. The system is adaptive with regards to the type of users and the type of tasks it supports. Information technology can help by creating adaptive systems or *platforms* that are flexible yet powerful. Two main features of IT systems drive systemic flexibility and adaptivity that are required for generative fit:

Customisation Systems should incorporate tailorable facilities and customisation tools that enable it to *user induced adaptation* (Mackay, 1991; Tam/Ho, 2006; Germonprez/Hovorka/Collopy, 2007). As it is impossible to design systems that fit all users and all situations the support of user actions should not be narrowly defined by strict rules but should be adaptable to a user's environment and an organisation. Tailoring the technology to user's needs should be a native concept in generative design to allow users to continually redefine and customise the services according to their usage patterns.

Automation Systems should incorporate artificial intelligence that enables *system-induced adaptation* (Weiser, 1993). Many customisation tools provide much value but also require user's attention in responding to changes in usage patterns. Designing adaptive systems that incorporate continuous learning and improvement such as awareness systems (Köbler et al., 2010a; Köbler et al., 2010b), allow users to shift resources from system operation to generating the desired outputs.

4.4.3 Generative Design is Open-Ended

Systems with high generative fit should be able to generate a virtually infinite number of configurations. They are inherently open-ended because it is evocative and because it is adaptive. By design, high generative fit provides the foundations for generating endless configurations. Two information technology-enabled features enhance open-endedness and subsequently the generative fit:

Peer-Production Peer-production refers to features that enable any individual or group to produce and share new and useful extensions of products or services at their own volition. Systems should incorporate peer-production facilities. Peer-production promotes innovation through collective action through evolutionary changes in response to market demands and emerging opportunities. This is only possible in a technological environment that is designed a priori with an *extensible architecture* and a social environment that provides the necessary incentives and normative support. For example, many open-ended systems encourage peer-production through the development of plug-ins or add-ons such by unaffiliated third parties.

Rejuvenation Systems should incorporate a *modular architecture* that supports a renewal process of the system. Renewal refers to both fine-tuning as well as radical change. The degree of modularity of a system influences the degree to which parts of the system may be changed and updated. Systems should also follow open development standards such as defined APIs.

In summary, systems that are evocative, adaptive, and open-ended can be characterised as systems with high generative fit and thus enhancing generative capacity within people (Avital/Te'eni, 2009).

4.5 Generativity According to Zittrain

The concept of generativity is also found in the work of Zittrain who provides a definition similar to the one given by Avital/Te'eni (2009): "Generativity is a system's capacity to produce unanticipated change through unfiltered contributions from broad and varied audiences" (Zittrain, 2008, 70). In his understanding, generativity fosters innovation and disruption.

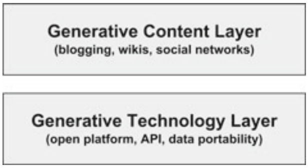

Figure 4.2: *Generativity on the technology and the content layer.*

According to Zittrain (2008, 71ff), five principal factors make a system generative:

- how extensively a system or technology leverages a set of possible tasks (*leverage*);
- how well it can be adapted to a range of tasks (*adaptability*);
- how easily new contributors can master it (*ease of mastery*);
- how accessible it is to those ready and able to build on it (*accessibility*); and
- how transferable any changes are to others - including (and perhaps especially) non-experts (*transferability*).

The five qualities reinforce one another and generativity increases with the ability of users to generate new, valuable uses that are easy to distribute. These new and valuable uses are in turn sources of further innovation (Zittrain, 2006).

Zittrain (2008) offers a useful structure for generativity by distinguishing between generativity on the *content layer* and generativity on the *technology layer*. We extend and refine the initial distinction made by Zittrain in the following paragraphs. Figure 4.2 displays the distinction graphically.

Content Layer The content layer contains actual information generated by and exchanged among a system's users (Zittrain, 2008). On the content layer, a generative system allows its users to generate and record information which is stored and made accessible by the system. Generativity on the content layer is enabled by generativity on the technology layer. Thus, true generativity on content layer is not possible without generativity at underlying technology layer (Zittrain, 2008). For example, early online forums where generative at the content layer because people could post comments to each other which where not screened by an administrator. Furthermore, people could choose to take up whatever topics they were interested in, irrespective of the designated labels for the forums themselves. For example, users were usually not hindered to post comments regarding a certain topic in a forum designated to a completely different topic. However, these online forums were not generative at the technical layer. The software driving these communities was stagnant. Forum users who were both interested in the communities' content and technically minded had few outlets through which to contribute technical improvements to the way the communities were built. Instead, any improvements were orchestrated centrally by the forum operator hosting the application.

Technology Layer While the content layer is concerned with actual (user-generated) content, the technology layer refers to the underlying architecture on which the content layer builds (Zittrain, 2008). Contrary to the content layer where participation is understood as a social activity that solicits and depends upon participation from the public at large, on the technology layer mainstream users balk and prefer technical experts to solve problems and develop the system further; here contributions are perceive as technical rather than social (Zittrain, 2008). Wordpress,[1] for example, can be considered generative at the technology layer. Contrary to early online forums which could not be changed, Wordpress offers a wide opportunity to configure the underlying software itself. Thus, a website based on Wordpress can be customised for nearly any purpose (e.g., group commentary, seeking help finding a lost wallet, expressing and then sorting and highlighting various political opinions). Hence, Wordpress is generative at the technology layer which makes it more generative on the content layer. Generativity at the technical layer can also enable new forms of group interaction as demonstrated by Wikipedia[2] where thousands of users independently work towards creating an online encyclopaedia.

A key requirement for generativity on the technology layer is the ability to transfer user-generated content from one system to another (Zittrain, 2008). If users are unsure how they can transfer the content generated in one system to another this can limit their willingness to invest into a system despite its generativity on the content layer. The concept of transferability of user-generated content is termed *data portability* (Zittrain, 2008, 176). Interestingly, Zittrain synonymously uses the term *generative technology* with the term *platform* (Zittrain, 2008, e.g., on pages 3 and 5). This hints at the general trend towards platformisation and the generative character of platform-based systems.

Generativity instigates a pattern both within and beyond the technological layers of the information technology ecosystem. As a result, we must appreciate the connection between generative technology and generative content. Zittrain (2008, 64) claims: "Our information technology ecosystem functions best with generative technology at its core." Although generativity on the content and technology layer is required for truly generative systems, generativity on the technology layer is more important. A system's limitations on the content layer (e.g., a missing function to do simulations) can be overcome by a generative technology layer as third-parties and technically versatile users can develop this functionality. Table 4.4 presents a combined model of generativity by mapping the system features proposed by Avital/Te'eni (2009) on the content and technology layer by Zittrain (2008). This mapping offers additional structure to the set of design directives and can thus ease the system design process. It also allows shifting the focus on generativity on the technology layer as this allows the extension of the system on the content layer.

4.6 Related Theories and Historical Review

Other studies have also examined how information technology can support creativity. For example, Greene (2002) suggests that creative outputs may benefit from computer applications with the following features: easy exploration and experimentation, engagement with content to promote active learning, functionality for knowledge processing, collaboration, iterative work, trial and error, and domain-specific actions. These seven characteristics overlap with a set of similar features recommended by Shneiderman et al. (2006) (see also Shneiderman, 2002 and 2007) which Greene acknowledges. Given a natu-

[1] `http://wordpress.org/` (last accessed 2010-10-26)
[2] `http://wikipedia.org/` (last accessed 2010-10-26)

Layer	*System Feature*	*Note*
Content Layer	D1: Visualisation	Users' content is displayed in different forms to allow discovery of new relationships and possibilities for contribution and interaction.
	D2: Simulation	Users' content is simulated to test it in multiple situations.
	D3: Abstraction	Users' content is displayed in different levels of abstraction to identify relationships.
	D5: Communication	Users can communicate their ideas with other users and exchange information.
Technology Layer	D4: Integration	Systems allows the integration of other components.
	D6: Customisation	Systems can be customised to allow adoption to different uses (e.g., idea collection, idea rating, idea development).
	D7: Automation	Systems allow automating certain steps of an innovation process.
	D8: Peer-production	Systems are open-ended and extensible with other system components.
	D9: Rejuvenation	Systems follow open development standards and offer easy upgrade paths.

Table 4.4: *Mapping of generative design patterns offered by Avital/Te'eni (2009) on the content and technology layer introduced by Zittrain (2008).*

ral relationship between generative capacity and creativity there is some overlap with the design considerations suggested above. However, the design directives proposed by Greene and Shneiderman do not follow an integrated framework based on top-level directives but rather offer only loose sets of criteria (Avital/Te'eni, 2009).

In addition to the system design considerations summarised in the previous section, the theory of generative fit also emphasises the general distinction between operational efficiency and generative capacity. On a more general level, similar approaches have been discussed, for example, by Krcmar/Astana (1986). An information system can open new opportunities (e.g., to achieve competitive advantage) but at the same time it also constraints its users within the boundaries of that system. This "duality" of opening up new possibilities while at the same time constraining users is an ever present aspect of information systems which can only be overcome by designing flexible, open-ended, and configurable systems that allow the easy adoption to changing user demands. This becomes even more important when considering that it might not be possible to correctly anticipate a user's interaction with a system (cf. the concept of a "tool in use" as described in Thomke, 2006).

There also is an interaction between technology and organisations. A well known interaction approach is *structuration theory* developed by Giddens (1984) who emphasises user involvement in innovation through processes of social interaction. Awareness of this interaction provides insight into the limits and opportunities of human choice, technology development and use, and organisational design (Orlikowski, 1992). Giddens and Orlikowski both emphasise the influence users have on technology (Krcmar, 2009).

4.7 Summary

The theory of generative capacity builds on the concept of generativity in the context of IS design (Avital/Te'eni, 2009). It holds that generative capacity, a user's ability to produce something new, can be better exploited by increasing the generative fit of an information system. Generative fit refers to the extent to which an IT system is contributing to evoke and enhance a user's generative capacity. A key point of generative fit is the distinction between features of information technology that support operational efficiency and features that support generative capacity. Most complex systems will require support for both task-related performance types and fine-tuning this blend becomes a key point in system design. The theory therefore provides design directives for systems to achieve high generative fit. In addition to this general distinction nine conceptualisations of system features for high generative fit have been presented under the three generative design directives: evocative, adaptive, and open-ended. A discussion of related theories and concepts, in particular creativity, presented a broader point of departure.

Thus, the concepts of generative capacity and generative fit address the emerging focus on creativity supporting aspects of computing systems as opposed to basic productivity enhancement (Fedorowicz/Laso-Ballesteros/Padilla-Meléndez, 2008). The concept itself does not distinguish between support for individuals and for groups. Consequently, the use of these concepts provides a different starting point than, for example, the study of computer supported cooperative work (CSCW). The focus of work related to CSCW has been software tools to specifically enhance the productivity of group work (Lewe/Krcmar, 1993), in particular by providing shared materials, and bridging time and space (Schwabe/Krcmar, 1996). Contrary, generativity and generative fit aim at supporting user's ability to produce something new.

As becomes clear from this discussion, in order to support innovation in service ecosystem a blend of both operational efficiency and generative capacity is required. The main concern of the system design process will become fine-tuning this blend of operational efficiency and generative capacity for the task of supporting innovation in service ecosystem as presented by the conceptual foundations (Chapter 3). This results in a seventh criterion for a solution:

Criterion 7: The system needs to fine-tune the blend between generative features and operational efficiency.

This seventh criterion adds to the answer of research question one from Section 1.2. The detailed distinction between generative capacity and operational efficiency serves as the guiding paradigm and unifying framework of this research. Figure 4.3 provides a summary of the requirement on the theory layer resulting from this chapter.

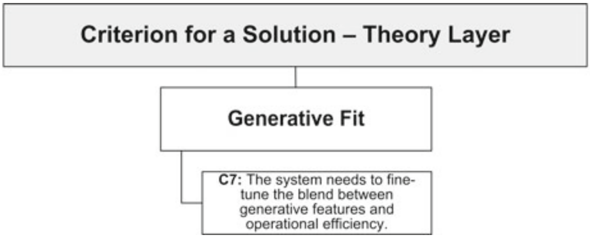

Figure 4.3: *Summary of criterion for tool-supported innovation management in service ecosystems on the theory layer.*

Chapter 5

Integrated System Design

In order to seriously think about the world and effectively act in it, some sort of simplified map of reality, theory, or concept is necessary. Without such intellectual constructs there is only “a bloomin’ buzzin’ confusion” (William James quoted in Kuhn, 1996). Hence, there is a need for a unified framework, a guiding paradigm, to order the requirements, artefacts, and system features developed in this work. This work thus develops a unified framework based on top-level directives as opposed to loose sets of design criteria used, for example, by Shneiderman et al. (2006). The term *framework* is used in the general sense of the word, referring to “a basic conceptional structure” (Merriam-Webster). The term is not used in the sense of an application framework used in software engineering referring to a collection of abstract and concrete classes that can be adapted and extended to create application systems (Sommerville, 2007). Using this unified framework avoids many of the difficulties encountered in system development such as opposing methods, loose or unjustified selection of “random” functions, large and complex systems, and an integrated evaluation where it is hard to attribute benefits to any individual system feature (Avital/Te’eni, 2009). We use the term *Integrated System Design* rather than just *system design* to stress this framework character and distinguish our unified design from that of individual tool functions. The Integrated System Design thus presents a system design formed into a unified whole. The unified framework uses the theory of generative capacity as guiding paradigm. As introduced above (see Section 4.2), the theory holds that generative capacity, a user’s ability to produce something new, can be better exploited by increasing the generative fit of an information system. It introduces the duality of supporting both operational efficiency and generative capacity.

Based on the unified framework the overall system design is developed. The system design has been developed following the research design presented in Section 2.3 based on theory-driven design and theory-based argument. As introduced in the research method section, constructs, models, and methods are important design artefacts of design research which then serve as the necessary foundation for an actual instantiation of an IT system. This chapter aims at elaborating and justifying all design decision and to demonstrate why the developed system looks the way it does in an inter-subjective traceable way. The system design developed in this chapter constitutes a major contribution of this research and serves to answer research question two from Section 1.2.

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The remainder of this chapter is organised as follows. The next section presents an open innovation perspective for service ecosystems (Section 5.1). Based on that perspective and the requirements collected in Chapter 3 the unifying framework of the TEXO Innovation Repository is presented (Section 5.2). Section 5.3 explains innovation support as part of an overall platform strategy. After analysing these organisational aspects the following Section 5.4 presents the system design. A critical reflection concludes the chapter (Section 5.5).

5.1 Open Innovation in Service Ecosystems

Open innovation proposes principles for the design of innovation systems in which innovation processes are open for external collaboration with a network of customers and suppliers (Section 3.5). It has been shown that implementing these principles increases innovation performance (Gassmann, 2006). The inter-organisational networks that are formed by service ecosystems have many links with the idea of open innovation (cf. Vanhaverbeke/Cloodt, 2006). As argued by Riedl et al. (2009a) an open innovation paradigm rather than a closed innovation paradigm is necessary for successful innovation development within service ecosystems. This is due to their heavy reliance on re-use, their reliance on new business models, and knowledge leveraging as services are implemented as software (Gassmann, 2006).

The focus of open innovation, however, is a single firm that thus tries to open its own innovation process (West/Vanhaverbeke/Chesbrough, 2006). Furthermore, it says little about which other actors are involved and how they interact and collaborate regarding innovation development (West/Lakhani, 2008). Service ecosystems can be seen as a catalyst for open innovation and thus offer an opportunity to extend the firm-centric concept of open innovation developed by Chesbrough and others (Chesbrough, 2006b; Chesbrough/Vanhaverbeke/West, 2006; Gassmann, 2006; Ogawa/Piller, 2006) by proposing a platform-centred interpretation.

The main aspect of service ecosystems is that of a central platform that brings all actors together. Companies try to extract ideas for service innovation from this central platform and use these ideas to create new or improve existing services (Riedl et al., 2009a). So, instead of a single organisation following the open innovation paradigm, a larger pool of companies bound together through a central platform follows the open innovation paradigm (Figure 5.1).

In such an environment each company would pursue their own innovation projects following the open innovation paradigm (cf. Section 3.5). However, they would share innovative ideas, feedback, and services within the boundaries of the service ecosystem in an open fashion. As actors voluntarily join the ecosystem with the aim of collaboratively developing and offering services, exchange within the boundaries of the ecosystem would be particularly active and intellectual property issues are expected to be less important. This does not mean, however, that no exchange with the world outside the service ecosystem is possible. Actors are also expected to cultivate an open innovation approach towards actors outside the service ecosystem.

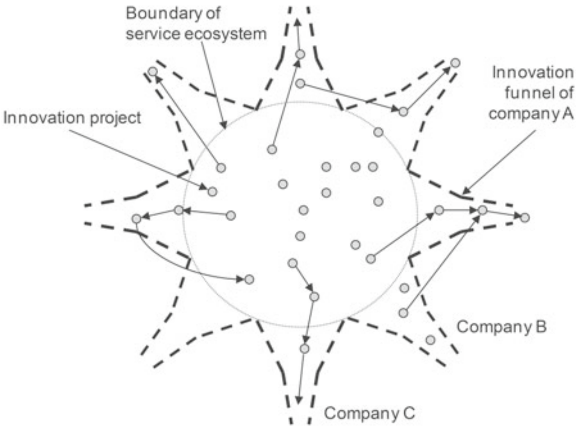

Figure 5.1: *Platform view of open innovation (Riedl* et al.*, 2009a).*

To jointly develop new products and services in an innovation network, different activities need to be performed by different types of roles. These roles characterise the types of activities involved and the type of contribution that are required. For successful innovation projects this is important to understand as the roles define the capabilities that actors need to contribute (Nambisan/Sawhney, 2008; Neyer/Bullinger/Moeslein, 2009). In a general concept of "network-centric innovation" Nambisan/Sawhney (2008) propose three types of innovation players:

Architect Architects trigger and catalyse innovation. Furthermore, they envision and direct innovation and attend to the innovation network. Architects are the central members in an innovation network; they provide the initial momentum, and define key elements of the network and the innovations to be carried out.

Adapter Adapters provide specialised knowledge or support and infrastructure services. Nambisan/Sawhney (2008) call them adapters because they adapt to the direction given by the architect. Adapters may possess highly specialised knowledge and expertise to solve unique problems during the innovation development.

Agent Agents act as mediators by liaising interactions, mediating knowledge transfer, and mediating innovation.

In a similar approach Steiner (2005) differentiates between two roles. A shaper as an entrepreneur in a central role offering a dominant design or standard, and a multitude of other organisations, called adapters, offer complementary products to that central design. Tapscott/Lowy/Ticoll (2000) differentiate between the following five classes of network participants:

- Context providers play a leading role through facilitating the interface between customers and the other network actors and lead the choreography and value realisation in the network.

- Content providers contribute the main goods, services, or information that constitutes the intrinsic form of value.
- Commerce service providers facilitate trading processes such as financial transaction management, security and privacy, logistics and delivery.
- Infrastructure providers provide the infrastructure on which the platform operates.
- Customers who not only receive value but also contribute value through co-creation.

While most open innovation studies have focused on the firm level (West/Vanhaverbeke/Chesbrough, 2006) the three works summarised above took a first step at analysing open innovation on an inter-organisational level. However, the resulting roles vary and need to be further conceptualised.

As this review of open innovation on an inter-organisational level shows, service ecosystems provide a promising environment for the implementation of these principles and thus maximising the benefit derived from open innovation (Riedl et al., 2009a). To accomplish this goal it is necessary to understand the actors involved in service innovation in service ecosystems and how these parties can contribute to and benefit from an open innovation system.

The following sections develop a conceptual framework of actors and their roles in an open innovation system for service ecosystems; the framework illustrates how open innovation can be implemented in a service ecosystems to increase innovation performance. The framework also shows how the current conceptual thinking about service ecosystems can be evolved to incorporate findings of open innovation research (see research gap presented in Section 3.4.5).

5.1.1 Collaboration Framework

In order to answer the questions, who are the actors involved in such an innovation ecosystems and what are their core competencies, this section first presents a consolidated view on the network roles and second an interaction model for innovation in service ecosystems.

From the description of the network roles a considerable overlap in core competencies and contributions that are expected from each role can be identified. Table 5.1 consolidates the roles proposed for both service ecosystems (Section 3.4.1) and networked innovation (above) and groups them under four main paradigms according to their core competencies and their contribution towards the innovation space of service ecosystems. First, the customer judges the created value and has requirements for new services (Berkovich et al., 2009). Second, the platform provider pushes an innovation project forward in the role of a leading player and establishes the main environment for the service innovation. Third, service provides offer various support services and specialised knowledge and follow the driver within an innovation project. Lastly, the broker engages in brokering between the providers and customers and engages in transforming ideas within the innovation space without offering services on its own.

	Customer	Platform Provider	Service Provider			Broker
Barros/Dumas 2006	Customer	Provider	Mediator		Specialist Intermediary	Broker
Nambisan/Sawhney 2008		Architect	Adapter			Agent
Steiner 2005		Shaper	Adapter			
Tapscott/Ticoll/Lowry 2000	Customer	Context Provider	Content Provider	Commerce Service Provider	Infrastructure Provider	

Table 5.1: *Consolidation of network roles (adapted from Riedl* et al.*, 2009a).*

According to their core competencies service ecosystem actors make different contributions to the innovation space. The innovation space represents possible service designs that may be reached (cf. Millar/Demaid/Quintas, 1997). In a setting with a central platform, such as service ecosystem described above, the platform forms a collective innovation space that defines the boundaries of trans-organisational, or networked, innovation. We argue that the contributions of the actors to the innovation space fall into three main areas: services, ideas for new services, and feedback related to service usage. This structure relates to studies of customer roles in product development where customer contributions have been classified as a source of ideas, as a co-creator through participation in product design and development, and testing and supporting products (Nambisan, 2002). Through the heavy reliance on re-using and re-purposing existing services, the variety of existing services strongly influences future service designs. The more services are available on the platform, the larger the innovation space of potential new services becomes. Thus, contributing a new service to the ecosystem may open completely new possibilities. Concrete service ideas or requirements are the most obvious source for service innovations as they directly imply possible design options. Finally, feedback from service users about existing services is a main source for incremental service innovations (Riedl et al., 2008). In addition to contributing to the innovation space, actors may also extract from and expand on knowledge from the innovation space to create new services. Brokers play a special role as they do not necessarily contribute new ideas but transform and refine already existing ideas in the innovation space (Hargadon/Sutton, 2000; Verona/Prandelli/Sawhney, 2006).

Using the consolidated roles customer, platform provider, service provider, and broker we developed a collaboration model (Figure 5.2). The model shows the actors and their contributions to the innovation space as described above. This role and interaction model serves as the blueprint for a tool to support innovation in service ecosystems. The model also highlights the concept of a central innovation space through with the different actors within a service ecosystem can communicate and exchange innovation relevant information. Table 5.2 shows each actor's relationship with the innovation space.

Although the roles are presented as quite distinct in the framework it has to be noted that within the scope of a single innovation project actors can switch between the roles they play. While driving one project as a service provider or architect, in another situation the actor may only contribute end-user feedback about the services consumed from suppliers. Thus, it becomes apparent that across multiple innovation projects a single actor may play different roles which is particularly emphasised through the heavy reliance on re-use so that every actor is expected to interact with others on multiple levels.

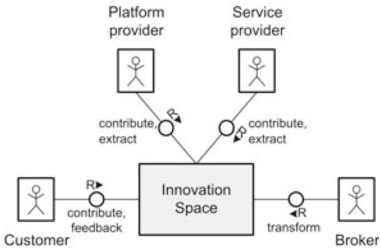

Figure 5.2: *Interaction model for innovation in service ecosystems (adapted from Riedl* et al.*, 2009a).*

Customer	
Contribute	Customers contribute ideas for completely new services. Customers contribute refinements (e.g., in the form of comments and community evaluation). Customers contribute requirements and needs (e.g., via innovation communities or lead user studies).
Co-production	Customers may become service providers by developing new services on their own through end-user development (e.g., user generated mash-ups, cf. Dörner et al., 2008); they become service providers themselves.
Feedback	Explicit - Customers provide explicit feedback regarding existing services through rating (e.g., five-star rating) or comments left through community tools provided by the platform. Implicit - Customers provide implicit feedback through actual service usage (e.g., if a service is used frequently users value the service which allows deriving ideas for service bundling; Riedl et al., 2008). In general, actual service usage indicates user preferences and willingness to pay.
Platform Provider	
Contribute	Platform providers supply the overall environment (i.e., platform APIs). Platform providers contribute ideas and comments about ideas to the innovation space.
Extract	Just like a regular service provider the platform provider extracts ideas to be implemented and new services to be offered. However, the platform provider has a different evaluation function in that it is focused on overall platform success. Hence, the platform provider is likely to fund ideas that benefit the entire platform even if not economically viable on their own.
Service Provider	
Contribute	Service providers contribute services to a service repository. These services can be used as building blocks for new services thus shortening time to market and easing implementation.

	Service providers contribute an idea for which they seek community evaluation or refinement. They may also contribute ideas as a form of requirement communication, thus requesting a new feature and playing the role of a customer. Service providers contribute new/improved service (which might be based on ideas submitted to the platform).
Extract	Service providers extract ideas from the ecosystem for implementation. Every service provider rates every idea from its own perspective and decides which idea is valuable. An idea valuable for company A might not be valuable for company B. This might be due to different business models or available resources. Thus, different actors will have very different views on the same set of ideas, each evaluating ideas according to its own standards.
Broker	
Transform	Brokers engage in transforming and refining ideas. This translates to a set of four sub-tasks: Brokers capture capture good ideas, keep ideas alive, imagine new uses for old ideas, and put promising concepts to the test (Hargadon/Sutton, 2000; Verona/Prandelli/Sawhney, 2006).

Table 5.2: *Actor relationships with the innovation space (adapted from Riedl* et al.*, 2009a).*

5.1.2 Summary

The framework shows the capabilities of the individual actors with regard to service innovation and how these capabilities can be exploited by the overall ecosystem to advance service innovation. This highlights the potential advantages that can arise through the constellation of various actors bound together by an ecosystem platform. Each actor benefits from the contributions of the other participants. End-users contribute knowledge about actual market demand either in the form of ideas or through feedback provided about the services they used. The platform provider contributes the overall environment of the ecosystem platform and serves as an architect to drive innovation projects by extracting and implementing ideas that are likely to benefit the whole ecosystem. Service providers contribute services that extend the innovation space and may thus allow new value added services to be composed. Conversely, they extract and implement service ideas that a provider deems valuable. Finally, brokers engage in transforming ideas already present in the innovation space.

The framework proposes a new way of thinking about an innovation ecosystem where each actor contributes to a collective innovation space rather than single companies pursuing their individual innovation projects. The framework serves as an interpretative scheme to structure and analyse each actor's contribution towards the innovation space. In the remainder of this work the model serves as a guide in leveraging the combined resources available in service ecosystems and can guide strategies for businesses to successfully participate in service ecosystems. Moreover, it becomes apparent that the different types of contributions require adequate tool support to facilitate networked innovation (see also the requirements presented in Chapter 3). The design challenge is to actually instantiate the concept of the innovation space as introduced above. The innovation space is the central interface through which the different capabilities by the various actors are linked together. It is the central artefact of communication.

Central Architectural Design The concept of a central innovation space linking the actors of an innovation ecosystem together based on the analysis of actors and their respective competencies serves as the central architectural design for the tool developed in this research.

5.2 Unifying Framework

This section presents a unifying framework for the overall objective of this research to develop a tool for supporting innovation management in service ecosystems. As introduced above, an open innovation paradigm rather than a closed innovation paradigm is necessary for successful innovation development within service ecosystems. In addition to the requirements derived from new service development (Section 3.3), service ecosystem specific requirements (Section 3.4), and open innovation requirements (Section 3.5) that form the subject domain this research is guided by the central realisation that productivity gain is no longer the single most important evaluation criteria of information system performance (Avital/Te'eni, 2009). Rather, a system's ability to increase creativity, reveal opportunities, and serendipitous discoveries is becoming more and more important. This type of system functions are related to generative capacity and are opposed to functions supporting operational efficiency (cf. Section 4.2).

The task of supporting innovation in service ecosystems requires a blend of both, operational efficiency (e.g., pushing ideas forward in the innovation process through to implementation) and generative capacity (e.g., coming up with new service ideas). For information system design the "main concern here is fine-tuning the blend of operational efficiency and generative capacity for the particular task characteristics" (Avital/Te'eni, 2009, 352). This resulted in the seventh criterion that a blend between generative and operational system features is necessary. Based on the requirements of developing electronic services in a service ecosystem setting on an organisational layer and the theory of generative capacity we developed a unified framework for tool-supported innovation management in service ecosystems.

The central idea of the unifying framework is to provide an actual realisation and instantiation of the concept of a central innovation space. The unifying framework would thus provide an implementation of the platform perspective on open innovation as an innovation support tool (cf. Section 5.1).

On top of the instantiation of the concept of a central innovation space a blend of support for both operational efficiency and generative capacity is required, i.e., achieving generative fit. As tool-supported innovation management for service ecosystems is a complex issue involving many different task aspects the main concern of the information system design process is thus fine-tuning this blend of system functions supporting operational efficiency and generative capacity. This duality, the detailed decisions regarding the mix between the two serves as the guiding paradigm and unifying framework of this research.

> This results in the **unifying framework** of a process-based, open-ended, central repository supporting both generative capacity and operational efficiency through the integration of special-purpose applications. Fine-tuning the blend between operational efficiency and generative capacity features is the main concern of the system development process.

The following paragraphs look at each of the key design elements (*central repository*, *process-based*, *open-ended*, and *special-purpose applications*) of the unifying framework in turn. The paragraphs highlight whenever one of the generative design directives (D1 to D9) from Table 4.3 is addressed.

Central Repository The central repository, a place for data storage and communication, of the unifying framework instantiates the concept of a shared innovation space. Following the platform perspective on open innovation and the model of diverse actors with different types of contributions and capabilities the central repository provides a central communication point which all actors of a service ecosystem can access. The system provides peer-production (D8) facilities through which actors within service ecosystems can produce and share innovation relevant information. The central repository also provides communication support (D5) for all actors within a service ecosystem.

Process-Based Pushing ideas forward in a formalised innovation process all the way from idea generation through to implementation is a vital success criterion of innovation projects (van de Ven, 1986; Froehle et al., 2000). To support operational efficiency and move ideas along the innovation process it is necessary to follow a defined procedure (Avital/Te'eni, 2009). The whole system is therefore process-based and supports automation (D7). The idea management is organised along a defined innovation process, thus allowing innovators to track and manage ideas across different process steps. Systems with high generative fit can be used by a diverse set of people in their respective environments (Avital/Te'eni, 2009). The innovation process supported by the system therefore has to be adaptive to various tasks and specific innovation scenarios (e.g., to support innovation both within large and small organisations). It has to be possible to customise the innovation process (D6). The process-based system has to allow both the definition of a process as well as the execution of that process. Through the process-based nature of the system it is possible to adapt and customise the amount of generative and operational efficiency features to a given situation. The system has to incorporate tailorable facilities and customisation tools that enable user induced adaptation (Mackay, 1991; Tam/Ho, 2006; Germonprez/Hovorka/Collopy, 2007). As it is impossible to design systems that fit all users and all situations (Avital/Te'eni, 2009), the support of user actions must not be narrowly defined by strict rules but has to be adaptable to a user's environment and an organisation's innovation requirements but at the same time operational efficiency must not remain out of consideration. Using built-in customisation tools allows users to play an integral role in the modification of the system in the context of its use.

Open-Ended As it is almost impossible to define the exact system scope, in particular in an area such as service ecosystems, it is necessary that the system can be extended by adding new things. Therefore, the system does not have a defined scope but is rather built with the paradigm of an open-ended platform in mind. The aim is to build the system as open and flexible as possible so that it can be extended with additional features and sub-systems. The system then offers high generative fit as it can generate a virtually infinite number of configurations. Furthermore, it is inherently open-ended because it is evocative and because it is adaptive (Avital/Te'eni, 2009). Two information technology-enabled features are necessary to enhance open-endedness and subsequently the generative fit: integration and rejuvenation (Avital/Te'eni, 2009). The integration aspect (D4) refers to the ability to incorporate additional tools, functions, and subsystems, for example, a system to support Delphi analyses of innovative ideas; possibly from related domains that allow overlaying or merging views or objects from different disciplines, practices, or organisations. Such an integrated platform can promote system-wide boundary crossing and cross-fertilisation (Boland Jr/Tenkasi/Te'eni, 1994; Riemer/Steinfield/Vogel, 2009; Cusumano, 2010a). The rejuvenation (D9) aspect refers to the system incorporating a modular architecture, open standards, and open interfaces in support of renewal processes. This implies in particular that the data model used to represent innovations needs to be flexible and extendible to allow the addition of new aspects. Furthermore, the system has to offer generic interfaces through which additional functions can be added.

Special-Purpose Applications Due to complexity, it is unrealistic to assume that a single tool can provide all necessary functionality for integrated innovation support in service ecosystems (e.g., integration of actors through a virtual community, a specialised search engine or other information retrieval application, tools for efficient evaluation and selection of ideas, or a visualisation of the idea pool). Complementing the aspect of open-endednes, the unifying framework aims at the integration of special-purpose applications that can be added to an innovation scenario on a custom basis. These applications can address additional requirements for generative or operational efficiency features within a given innovation scenario. Through the integration of special-purpose applications it is possible to address the design directives for visualisation (D1), simulation (D2) through a service runtime environment (Spillner et al., 2009), and abstraction (D3).

In addition to special-purpose applications providing support for generative capacity and operational efficiency features, *management functions* are necessary. The scope of the management functions is to control the process-based aspects of the system, to coordinate the integration of special-purpose applications, and allow the general customisation of the system. These management functions are targeted at a specific user role, namely that of an innovation manager, who possesses additional access rights compared to a regular user of the system.

5.3 Innovation Support as Part of the Platform Strategy

The unifying framework and the requirements collected above result in the design of tool-supported innovation management as an open, process-oriented platform that provides access to a shared innovation space for all actors of the service ecosystem. Based on the actors of service ecosystems (Section 3.4) and more generic model commonly used in cloud computing (Leimeister et al., 2010), three layers can be identified: platform layer, service provider layer, and customer layer. These three layers need to be understood in a functional way, not in a technical sense.

Platform Layer As the aim of the platform provider is to grow its ecosystem it is also necessary for the platform provider to ensure adequate innovation and communication support. Hence, the platform provider is assumed to be the provider of the innovation platform. The innovation platform can be seen as a core component of the service ecosystem platform similar to the service runtime environment or the service registry. Similar to the provision of good software development kits (SDKs) good innovation support could become a platform provider's competitive advantage leading service providers to choose one platform over another.

Service Provider Layer Service providers are interested in offering new services and improving existing services in order to maximise their profits. In order to do so, they are interested in harnessing the best innovation support available. Moreover, they are interested in collecting as much feedback from their customers as possible to develop new and improve existing services.

Customer Layer Customers use the services offered to them on the service ecosystem platform. They look for services that deliver the highest possible value for them and the availability of valuable services is a key criterion for them in choosing one platform over another.

The interaction between the actors on the three layers is depicted in Figure 5.3. Customers contribute ideas and requirements that they might have to the innovation tool. A service provider uses the innovation tool provided by the service ecosystem platform. Using the innovation tool the provider develops new or improved services which are again deployed on the service ecosystem platform. These new/improved services thus become available on the platform for use by customers. The value of the new/improved services is then delivered to customers who use the services provided by the service ecosystem.

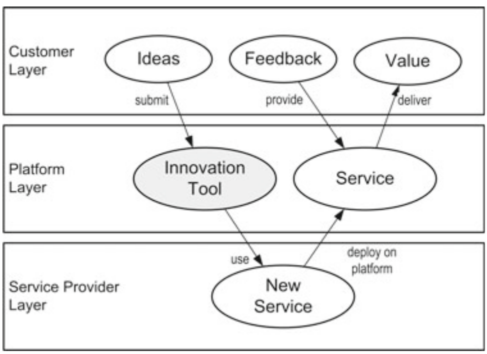

Figure 5.3: *Interaction structure of TEXO Innovation Repository.*

5.4 System Design

This section presents the architectural design approach taken in this research to translate the unifying framework into a system design which is necessary for implementation. An architectural style is a pattern of system organisation (Garlan/Shaw, 1993). Architectural design is a creative process through which the designer tries to establish a system organisation that will satisfy the functional and non-functional system requirements (Sommerville, 2007). System design is a creative activity, i.e., the result is non-deterministic and dependent on the designer's experience and the resulting output is difficult to evaluate (Sommerville, 2007).

The overall system is decomposed into subsystems based on the concept of special-purpose applications. Through the use of an open integration mechanism this decomposition will allow the flexible addition of user-defined features. Moreover, the decomposition in subsystems along the definition of special-purpose applications will allow the stepwise implementation of the system. Special-purpose applications will offer support for 1. generative features 2. operational efficiency features, and 3. administration features.

As is common for large systems the architecture does not conform to a single style (Sommerville, 2007). Different parts of the system are designed using and combining different architectural styles. The basic strategy used to structure the system, the system organisation, is the shared data repository style. In the so called *repository model* all shared data is held in a central database that is access by all other subsystems. This is opposed to a system design where each subsystem would maintain its own database (Sommerville, 2007). This design is common for systems that use large amounts of data and is suited to applications where data is generated by one subsystem and used by another as is the case for the TEXO Innovation Repository (Sommerville, 2007).

Sommerville (2007) mentions the following advantages and disadvantages of a shared repository:

- It is an efficient way to share large amounts of data as there is no need to transmit data between subsystems.
- However, subsystems must agree on the repository data model. This implies a compromise between the specific needs of each tool. Moreover, it can be difficult or impossible to integrate new subsystems if their data model does not fit the agreed schema.
- Subsystems that produce data need not be concerned which how that data is used by other subsystems.
- However, evolution may become difficult as a large volume of information is generated according to an agree data model. Translating this to another model may be difficult or even impossible, and certainly expensive.
- Activities such as backup, security, access control and recovery are centralised.
- However, specific requirements for of subsystems in that area may be different. The repository model forces the same policy on all subsystems.

- The model of data sharing is visible through the repository schema. It is straightforward to integrate new tools as long as they are compatible with that model.
- However, it may be difficult to distribute the repository over a number of machines.

Due to its advantages regarding the efficient way of data storage and independent evolvability of client applications we chose the repository model. To address the above mentioned shortcomings the next chapter presents a data schema that will be used for data storage. Using Semantic Web technology the data model can be extended thus avoiding the need for compromise during the initial design. The repository model will be implemented using the client-server model. In the client-server model a system is organised as a set of services and associated servers and clients that access and use the services (Sommerville, 2007). More specifically, the system will be Web-based: the clients used to access the services provided by the server are simple Web browsers. The server, on the other hand, implements the repository through a set of services which can be accessed by the clients. Subsystems will also be implemented using the client-server model. A subsystem server component will communicate with the repository server, while the resulting functionality will be accessed by clients through a Web browser (Orfali/Harkey, 1998). Clients will be so called *thin-clients* with all data processing performed by the server (Sommerville, 2007).

The repository server itself will follow a layered structure. The layered model organises a system into layers, each of which provide a set of services. Each layer provides an abstraction from the previous layer and thus supports the incremental development of systems and reduction of complexity on the upper layer. A layered model is also changeable and portable as long as the interfaces between layers are not affected (Sommerville, 2007). The system is decomposed into three layers commonly used in client-server architectures: a data management layer, an application layer, and a presentation layer. The presentation layer is concerned with presenting information to the user and with user interaction. The application layer is concerned with implementing the logic of the application, and the data management layer is concerned with all database operations (Sommerville, 2007). As suggested by Sommerville (2007) the three architecture styles repository model, client-server, and layered model are used together for the implementation. On a generic level, the functionality offered by the system will be distributed between two user roles: users and administrators. While users can access the overall functionality offered by the special-purpose applications, certain managerial functions like system setup and configuration are reserved for administrators. Figure 5.4 illustrates an abstract organisation of the architectural design.

The key challenge implementing the architectural design is to implement the integration-enabled data repository. Mayor requirements of the repository are 1. to be able to handle a large idea pool, 2. the definition of the shared data model to allow the integration of various special-purpose applications, and 3. to be extendible in nature to accommodate for new requirements. In addition to technical interoperability, semantic interoperability is a major concern. Different actors form different organisations, working with different subsystems may have a different (semantic) understanding of the data accessed through the repository.

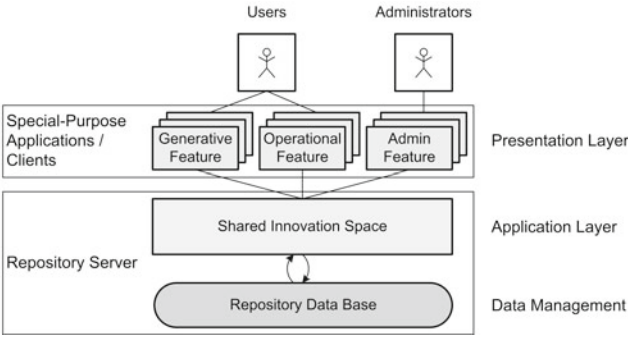

Figure 5.4: *Generic architecture for innovation support in service ecosystems implementing the unifying framework.*

Technical System Role	*Summary*
Community Member	Post ideas and comments, rate ideas, develop ideas, upload attachments. In general: create and develop ideas.
Innovator	Setup and configure an innovation scenario and control the innovation process.
System Administrator	Setup and administration of the overall system.
System	External computer systems that access the TEXO Innovation Repository through technical interfaces on the back-end.

Table 5.3: *Summary of technical system roles.*

5.4.1 Mapping of System Roles

Criterion C4 (Section 3.4) calls for support for the integration of different actors with support for different tasks and different capabilities. Consequently, a role model is required for the TEXO Innovation Repository. Abstracting the interaction with the innovation space from Section 5.1.1 to the roles that a user plays with respect to the system, two general roles can be identified: the role of a basic end-user without any special rights which will be called *community member* and that of an innovation manager who has special rights in the system which will be called *innovator*. In addition to these two functional roles we identified two additional, technical roles. A *system administrator* will be responsible for general administration tasks as well as a *system* role which represents other computer systems that interact with the TEXO Innovation Repository through the use of technical interfaces. The following paragraphs explain each of the resulting four roles in more detail. Table 5.3 provides a summary of the system roles.

Community Member The integration of external resources into the innovation process plays a crucial role in the overall system concept. External resources are integrated into the innovation process as community members. The community member engage in the development of service innovations by submitting own ideas and discussing other members' ideas. Both kinds of contributions are vital for the system's performance since innovation is achieved by combining different thoughts and opinions.

Innovator The innovator is the beneficiary of the system. The innovator is interested in extracting innovative ideas and turns to the TEXO Innovation Repository to collaborate with other users to develop them. Furthermore, it is the innovator's responsibility to set-up innovation scenarios by defining the steps in the innovation process as well as the terms and conditions. By doing this the innovator can push the creative potential of the community members in a certain direction. The innovator also decides when an innovation phase is over or when the process has to be restarted in parts or as a whole. The innovator is also responsible for planning the integration of the other innovation applications, the special-purpose applications introduced above, into a holistic innovation process.

System Administrator The system administrator is the super user of the system. Users of this role are responsible for setting up the overall system, providing the basic settings and the look and feel of the application. The system administrator is able to modify the look-and-feel of the overall system by changing the arrangement of individual components and therefore adding or removing functionality. Moreover the system administrator can choose and customise the look-and-feel of the overall system.

System This role does not refer to human user but other computer system that interact with the TEXO Innovation Repository. A central aspect of the unifying framework is that of an open-ended platform that is able to connect and integrate various special-purpose applications. The system role is used to represent other computer systems connecting to the TEXO Innovation Repository.

Roles and Authentication In order to work with the TEXO Innovation Repository users will have to first register with the system and then log-in using the credentials assigned during registration. This is a mandatory step for all roles (except the system role which does not access the Web-based front-end). All registered users are automatically assigned to the role community member which allows them to add ideas, write comments, and generally explore the pool of submitted ideas. The system administrator can grant innovator rights to a user by adding the innovator role to that user. The system is not limited to a single innovator but several innovators are expected to work with the system simultaneously.

Table 5.4 provides a detailed mapping between the actor relationships with the innovation space identified in the collaboration framework on the system roles.

5.4.2 Design Rationale and Course of this Research

The previous sections introduced the concept of a central innovation space as the main architectural design. This architectural design has then been refined through the unifying framework which introduces the concept of a process-oriented, open-ended central repository that supports both generative and operational features through the integration of special-purpose applications. We identified fine-tuning this blend between generative and operational system features as the central challenge of the system design process (criterion C7). Following our research design (based on theory-driven argumentation; Figure

Functional Role	*Technical System Role*	*Explanation*
Customer: Contribute	Community Member	Customers contribute ideas and comments through the generic community member function.
Customer: Co-production	Innovator	A customer becoming co-producer becomes a service provider.
Customer: Feedback	Community Member	Explicit feedback is simply contributed as a community member to a community function.
Customer: Feedback	System	Implicit usage feedback is made available directly through the integration of a special-purpose application linking the innovation space with the service runtime.
Platform Provider: Contribute	Community Member	Analogue to the customer role, platform providers can contribute ideas and requirements to the innovation space through the community member role.
Platform Provider: Extract	Innovator	The platform provider can manage its own innovation projects through the innovator role.
Service Provider: Contribute	Community Member	Service providers contribute ideas and requirements to the innovation space through the generic community member role.
Service Provider: Extract	Innovator	Service providers manage their own innovation projects to extract ideas for implementation.
Broker: Transform	Innovator	Capture ideas, keep ideas alive, imagine new uses for old ideas, put promising concepts to the test.

Table 5.4: *Mapping of functional roles from an organisational layer to system roles on a technical layer.*

2.7) this section presents the complete design rationale guiding the overall system design. System design is a complex and creative process. It involves design decisions on different layers. This section presents the design rationale for the overall system design. It gives a “bird’s eye” perspective on the TEXO Innovation Repository. The aim is to explain, why the systems look the way it does. This section elaborates all design decisions of the theory-driven design process to achieve the overall design goal of providing IT support for innovation in service ecosystems. The resulting IT system involves additional design decisions on a finer grained level. Decisions on the more granular level are described later in the prototype chapter of this work (Chapter 7).

The complete system design is developed in four design phases to improve on the unintended side effects of the previous design phase and to satisfy unrealised ends and thus to address the key requirements identified in Chapter 3 and Chapter 4. Design arguments are grounded in kernel theories from the extant body of knowledge on open innovation, group support systems, and cognitive theories related to evaluation and contribution behaviour. In doing so, this work ensures cumulative design research and enables reasoning about the resulting behaviour of the prototype prior to instantiation. In particular, it is possible to reason about the tradeoffs that can be expected by each system design decision.

Design phase one develops a basic innovation portal that allows the integration of external sources into the innovation process. It serves as a base-line system on which the other phases build. Design phase two develops a process-oriented, open-ended technical foundation that allows the systematic extension of the system through both, generative capacity and operational efficiency features. Phases three and four design an operational efficiency feature (an idea rating mechanism), and a generate capacity feature (a mechanism for user guided interaction) as proposed by the theory of generative capacity. Figure 5.5 provides an overview of the four design phases. Figure 5.6 at the end of this section shows the complete theory-based argumentation of the four design phases. While it is primarily intended as a summary, it is also useful at this point because it graphically illustrates the logic of the design arguments. The following sections provide detailed argumentative reasoning for the four design phases using the steps introduced in the research design in Section 2.3: 1. cause-effect relationship, 2. means-end relationship, 3. program, 4. unintended side effects, and 5. tradeoffs.

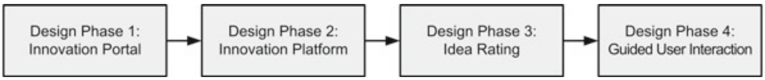

Figure 5.5: *Course of this research in four design phases.*

5.4.2.1 Design Phase One: Innovation Portal

The artefact resulting from the first design phase is a standard innovation portal which will serve as a base-line on which the other components can build. The following paragraphs explain the theory-driven design rational for this design phase in detail.

Cause-Effect Building on the concept of open innovation (cf. Section 3.5) design phase one plans a generic tool that allows the integration of external sources into the innovation process. Although it has not been formalised as a kernel theory using a cause-effect relationship in the narrow sense, the concepts underlying the open innovation paradigm can be summarised as follows. First, the integration of external sources of innovation into a company's innovation process increases its reach (as opposed to internal R&D) and thus creates more ideas (open innovation ⇒ more ideas). Second, the integration of external sources not only increases the reach but also the depth, in particular diversity, which has a positive effect on innovation quality (open innovation ⇒ idea quality). Overall, open innovation has been found to increase a company's innovativeness. In summary, the cause and effect relationship can be expressed as: integration of external sources of innovation ⇒ increased idea quantity and quality.

Means-End The effect of open innovation can directly be transformed into the aim ("is end") of the design theory: more and better ideas. Consequently, the aim of the design theory is the integration of external sources into the innovation process. Various means ("is means") exist for the integration of external sources into the innovation process, most notably innovation portals, ideas competitions, and toolkits (cf. Section 3.5). As the overall design goal is to support continuous innovation (cf. criteria for a solution C1, C2, and in particular C6) we chose an innovation portal as the means to integrate external actors into the innovation process. Furthermore, ideas competitions and toolkits aim mainly at the integration of end customers into the early phases of the innovation process (cf. Bretschneider, 2010). However, in the context of service ecosystems, networked innovation is predominantly resulting in a variety of actors working together, not only end customers. Hence, an innovation portal is a better means than ideas competitions or toolkits. Consequently, we deem an online innovation portal as a suitable means to influence the cause of the "open innovation theory" (integration of external sources of innovation).

Tool The component resulting from the first design phase is a standard innovation portal. It serves as a base-line framework on which the other components build. It is based on an empirical analysis of existing innovation portals on the Internet such as those operated by Starbucks, salesforce.com, and Innocentive (cf. Section 6.3). The system implements standard features such as submitting ideas, exploring ideas that have been submitted by other community members, writing comments, and rating of ideas. It is important to note that the aim the first component is not to provide a major contribution in itself. It is simply necessary as a base-line for the following components and experiments: unfortunately much implementation is necessary to demonstrate even a little.

Unintended Side Effects Several side effects can be expected from the use of an innovation portal which are already known in advance prior to actually developing the innovation portal. First, in the absence of a facilitator and emergent group processes it is difficult to control the innovation process (Fjermestad/Hiltz, 2001). The analysis of (Di Gangi/Wasko, 2009) demonstrates that users of an innovation portal frequently fail to elaborate and consolidate their individual contributions in such a way that the resulting ideas can be absorbed and implemented by the firm interested in the innovation. Second, the innovation portal will add to the collection of applications that a company uses to support their innovation activities (e.g., an employee suggestion system, a CRM system, or a group support systems such as GroupSystems ThinkTank to support brainstorming workshops). Consequently, the ideas generated using various innovation support tools will reside in silos without the ability of integration. This counters in particular criterion C2 to support the different phases of the innovation process in an integrated fashion. In addition to these unintended side effects several unrealised ends remain, in particular functionality relating to a process-oriented, open-ended repository.

Tradeoffs To alleviate the unintended side effects of ideas residing in application silos, the inability to consolidate contributions in such a way that ideas can successfully be implemented, and to satisfy unrealised ends of a process-oriented, open-ended platform, a central repository becomes necessary that allows the integration of different innovation tools, including the innovation portal proposed in this design phase. From this results the major challenge of the definition of the data schema which can be used to store data in a central repository and thus to solve the integration problem. Consequently, difficult system integration and interoperability issues are necessary tradeoffs as are an increase in complexity. These tradeoffs forces the start of a new design cycle which starts the second design phase.

5.4.2.2 Design Phase Two: Innovation Platform

The application resulting from the first design phase will allow the integration of external sources of innovation into a company's innovation process through the use of an innovation portal. However, several unrealised ends remain: in particular the requirements of process-oriented, open-ended, central repository that allows the integration of special-purpose applications. Together with the unintended side effects of an uncontrolled innovation process and an additional tool in the application portfolio a second design phase becomes necessary. This design phase develops the design for an innovation platform that can serve as the central innovation space derived at the beginning of this chapter. The following paragraphs explain the theory-driven design rational for this design phase in detail.

Cause-Effect Based on the overall design goal, criterion C7 demands that it will be necessary to fine-tune the blend between generative features and operational efficiency. Consequently, the second design phase builds on the theory of generative capacity as kernel theory (Chapter 4). The theory can be expressed in a cause-effect relation ship as follows: generative fit ⇒ better use of generative capacity (Avital/Te'eni, 2009). Section 4.3 highlights the relationship between generativity and creativity. The section concludes that the concept generativity is more suitable to guide system development than the concept of creativity.

Means-End The effect of the theory of generative capacity can directly be transformed into the aim ("is end") of the design theory: more and better ideas. Consequently, the aim of the design theory is to achieve generative fit through balancing system features that support operational efficiency and generative capacity. In accordance with the central architectural design and the unifying framework a suitable means to achieve this goal is the design of the system as an open-ended, process-oriented platform ("is means"). Through the process-orientation, operational efficiency can be supported and it can be ensured that ideas can be pushed through the innovation process (van der Aalst/van Hee, 2004). Through the open-ended nature of the platform, additional special-purpose applications can be added to support generativity. In summary, the artefact function "process-oriented, open-ended platform" is mapped on the theory cause "generative fit," and the predicted effect "better use of generative capacity" satisfies the design goal of innovation support for service ecosystems.

Tool The program develops the vision of an open-ended and process-enabled system. The resulting application will allow the integration of external special-purpose tools that can be freely configured and ordered to support any number of innovation scenarios and innovation processes. The program raises in particular two central aspects. First, a data schema to implement the concept of a central innovation space that allows the integration of external applications is necessary. Chapter 6 develops an ontology-based approach to solve this integration problem in order to achieve open-endedness. Second, a workflow implementation including configuration and management functions is necessary to realise the necessary process-orientation. The resulting innovation platform should then provide open-ended, flexible tool support for both generative capacity and operational efficiency features.

Unintended Side Effects Based on the approach of theory-based argumentation, a set of unintended site-effects can be expected from this first prototype. First, as ideas from several tools are combined in a single repository, it is likely to result in information overload through ideas from different tools. From this results both a quantitative issue as well as a semantic issue. First, as ideas from different tools are combined in a central repository the amount of ideas will increase. Consequently, the system has to be capable of handling large idea sets. Second, as ideas generated independently using different applications are combined in a single repository, these ideas are likely very similar to each other which results in duplicates (Di Gangi/Wasko, 2009). Prior research shows that more than 30% of ideas generated by independent contributors are redundant. Furthermore, problems to organise many contributions can be expected (Phang/Kankanhalli, 2008b).

Tradeoffs Up until this point the system design predominantly supports generative activities through the integration of external sources of innovation and the collection of ideas from different applications in a central repository. This results in large idea sets, redundancy, and an uncontrolled process. A clear tradeoff is consequently to introduce more process structure, operational efficiency, and to consolidate redundant contributions.

5.4.2.3 Design Phase Three: Idea Rating Mechanisms

The integration of a large amount of users and the additional integration of external tools will see the repetition of identical ideas. Furthermore, a predominant support of generative capacity results in an uncontrolled innovation process. This is due to an uncontrolled process as opposed to a more structured process in traditional group support systems where moderators play an important role in ensuring successful outcomes (Nunamaker/Chen/Purdin, 1991; Fjermestad/Hiltz, 2001). This phase designs a specialised idea rating mechanism that allows the evaluation of large sets of ideas in online innovation portals.

Cause-Effect Research on group support systems has found a strong correlation between process structure and outcome quality and user satisfaction (Nunamaker/Chen/Purdin, 1991; Fjermestad/Hiltz, 2001). In the context of synchronous group support systems process structure is usually achieved through the use of a moderator, or facilitator (Nunamaker/Chen/Purdin, 1991; Fjermestad/Hiltz, 2001). Here, idea rating and evaluation methods are a standard approach to implement converging innovation phases. This can be formulated as a cause-effect relationship as follows: decision-oriented task structures lead to converged results.

Means-End The effect of the kernel theory can again be transformed directly into the aim ("is end") of the design theory: filter and reduce the amount of ideas. As mentioned above, a suitable means to achieve this goal is the use of idea rating mechanisms which are commonly used in group support systems ("is means"). This results in the mapping between artefact function (idea rating) and theory cause (decision-oriented task structure) as well as the mapping between requirements and theory effect: that the predicted effect (converged results) satisfies the requirements (development and selection of innovative ideas for implementation as new services).

Tool The third component thus implements an operational efficiency feature: an idea rating mechanism. Due to the recent development of the open innovation field, no design theory is available to guide the exact design of an idea rating mechanism in online innovation communities. Therefore, we chose to implement three different rating mechanisms and evaluate them using a field experiment in order to determine which rating mechanism works best in the context of online innovation portals.

Unintended Side Effects An idea rating mechanism, in principal, works to filter and reduce the amount of ideas. However, if too many duplicate ideas with a varying degree of elaboration exist, idea ratings will be dispersed across all those similar ideas. Furthermore, raters are likely to move from one choice to another depending on the mix of recognised problems, the choices available, and the mix of solutions available for problems depending on the granularity and covered aspects of an idea (Cohen/March/Olsen, 1972). This is likely to result in low rating quality due low quality of the "input" into the rating process.

Tradeoffs A possible tradeoff to this problem is the deliberate design choice to limit user's possibilities of contribution (cf. concept of *process restrictiveness*, Wheeler/Valacich, 1996). This will result in a loss of creative input through a guiding of user interactions, but this could result in more fully, and more consistently elaborated ideas which will then positively influence rating quality.

5.4.2.4 Design Phase Four: Guided User Interaction

The computer system resulting from the previous three design phases will suffer from duplicates, ideas of low quality and low maturity. This design phase tries to alleviate these shortcomings and unintended side effects through the design of guided user interaction. Furthermore, the overall innovation process becomes increasingly uncontrollable due to the number of contributions. Based on this reasoning, this component implements the function of guiding and channelling external contributions to the innovation process in a meaningful way.

Cause-Effect With increasing numbers of ideas posted in an open innovation portal it becomes increasingly difficult to nearly impossible for users to gain awareness of what ideas already exist and how their own knowledge could contribute. Kornish/Ulrich (2009), for example, demonstrate that the independent articulation of opportunities (i.e., ideas) results in up to 32% redundancy. This results in unchannelled contributions, and duplicate ideas that are of low quality and low maturity (cf. Bansemir/Neyer, 2009). Contribution behaviour theory (Olivera/Goodman/Tan, 2008) helps to understand contribution behaviour in the context of distributed organisations. The theory introduces a set of request and technology characteristics that lead to desired contributions. This can be expressed as a cause-effect relationship: awareness, search and match, and formulation and delivery $\Rightarrow$ contribution.

Means-End The effect of the theory (contribution) can directly be transformed into the aim ("is end") of the design theory: elaborated ideas and a reduction of duplicates. Consequently, the aim of the design theory is to achieve better structured user contributions. To achieve this goal, the kernel theory proposes three effect constructs: awareness, search and match, and formulation and delivery. In the system design process these can be translated into corresponding means of a design theory ("is means"). We propose to use duplicate detection to achieve awareness, to use a pop-up to facilitate a user's search and match activity, and finally to use Semantic Web technologies to facilitate the formulation and delivery activity.

Tool The tool implements the duplicate detection through a clustering algorithm that is able to identify similar ideas. Based on the identified ideas, a pop-up presents additional information to the user to ease the cognitive search and match process. Finally, through the use of semantic technologies additional contribution options can be offered that allow the user a simple way to formulate and submit a contribution.

Unintended Side Effects It can be argued that two unintended side effects are likely to result from our design of user guided interaction. First, compensation of the idea owner will likely become more difficult when several users work together to elaborate ideas in a joint effort. Related to this issue is a second possible side effect: as compensation of the idea owner becomes more difficult, this could lead to a discouragement of users. Users could then refrain from contributing ideas to a common idea pool if the compensation mechanisms are unclear.

Tradeoffs Following the design rationales just presented all system requirements (C1-C7) should adequately be satisfied at this stage. In particular, a blend between operational and generative features has been achieved through the idea rating mechanism (operational efficiency) and the guided user interaction (generative capacity). Furthermore, the unintended side effects of the previous design phases have been addressed. The unintended side effects resulting from this design phase (compensation and discouragement) can be countered by the design of adequate incentive mechanisms rather than technical issues. Consequently, for the design of tool support for innovation management in service ecosystems the remaining side effects are only of limited influence. In summary, the unintended side effects are expected to be of only minor magnitude and can be accepted. Following the concept of satisficing (Simon, 1969) we propose that an overall successful system design has been reached that satisfies all system requirements and the design process should be stopped after the fourth cycle.

5.4.2.5 Summary of Design Rationale

This section described the design rational for the overall system design. The focus of the argumentation was on the general structure of the four design phases. The design rationale in particular presented arguments why the specific kernel theory has been used and why four design phases have been necessary to satisfy the criteria for a solution (C1-C7). After the fourth design cycle the unintended side effects are marginal and all requirements have been satisfied. The detail design decisions mapping the specific aspects of the design theories on system features is presented in the chapter describing the prototype implementation. Figure 5.6 summarises the complete theory-based argumentation of this research.

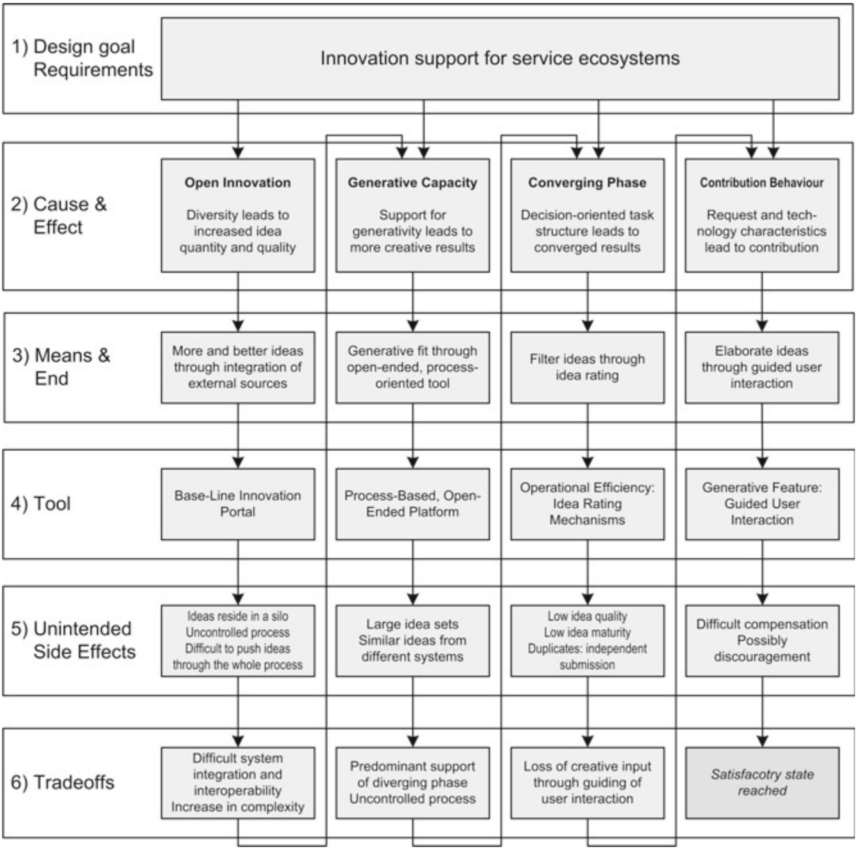

Figure 5.6: *Complete theory-based argumentation for this research.*

Table 5.5 summarises the instantiations of the design theory used in this research. The theory of generative capacity serves both as a kernel theory for the design product (i.e., how to design a system that supports generativity and achieves generative fit?) as well as a design process theory that provides a quality metric for a successful design process: has blend between generative and operational features been achieved?

5.4.3 System Details

This section provides additional details of the TEXO Innovation Repository related to implementation and technical aspects. As noted above, the TEXO Innovation Repository follows a classical three tier application approach with a Web-based front-end. It consists of

Component	*Description*
	Design Product
Meta-requirements	The criteria for a solution collected in Chapter 3.
Meta-design	Unifying framework and Integrated System Design (Chapter 5).
Kernel theories	Various kernel theories will be used during the design (in particular generative capacity, contribution behaviour theory, and various theories from social science about rating behaviour).
Testable design product hypotheses	Users will collectively develop innovative, well elaborated ideas for new services. They are also able to effectively select the best ideas for implementation.
	Design Process
Design method	The theory-driven design process described in Section 2.3 and the resulting instantiation of this process described in Section 5.4.2.
Kernel theories	Theory of generative capacity.
Testable design process hypotheses	A satisfactory blend between generative and operational features has been achieved.

Table 5.5: *Instantiations of the design theory used in this research.*

- a database back-end implemented by a MySQL[1] database,
- a middleware component that performs all data access functions both for the Web-based front-end as well as for other innovation systems interacting with the repository provided by a Tomcat[2] server, and
- a Web-based front-end implemented through a set of portlets running in a Liferay[3] portal server.

The system is written in the Java[4] programming language using the portlet[5] technology. We chose the Java portlet system to achieve a flexible design that allows the easy extension of the system through additional components. Through the well-defined interface and open standard the portlet design allows us to satisfy the generative design directive D9 "Rejuvenation." There are in particular two types of portlets: those providing management functionality to the innovator and those providing community member functions. The Web-based front-end uses the Liferay portal technology. Administration functions performed by the system administrator role introduced above are standard functions provided by the Liferay portal system and are not discussed in detail here. Sezov (2008) can serve as a good reference. Furthermore, Eclipse[6] has been used as the developing and testing environment. Figure 5.7 shows the detailed architecture of the TEXO Innovation Repository. External systems accessing the repository through the Web-service interface are depicted in the grey boxes.

[1] `http://www.mysql.com/` (last accessed 2010-10-26)
[2] `http://tomcat.apache.org/` (last accessed 2010-10-26)
[3] `http://www.liferay.com/` (last accessed 2010-10-26)
[4] `http://java.com/en/` (last accessed 2010-10-26)
[5] `http://jcp.org/en/jsr/detail?id=168` (last accessed 2010-10-26)
[6] `http://www.eclipse.org/` (last accessed 2010-10-26)

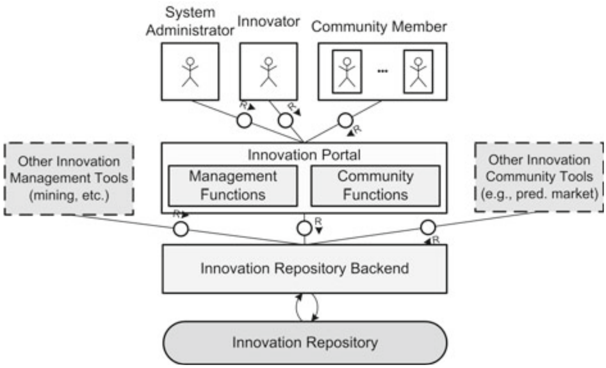

Figure 5.7: *Detail architecture of the TEXO Innovation Repository.*

5.5 Summary

This chapter first presented a platform perspective on open innovation introducing the concept of a shared innovation pool. The collaboration model then detailed the actors involved and their respective contribution towards such a shared innovation pool. Second, the unifying framework presented an overall tool concept for innovation support in service ecosystem. The unifying framework proposes to think of such a system as an open, process-oriented platform that allows addressing generative features and operational efficiency features through the integration of special-purpose applications. Finally, an architectural design of the TEXO Innovation Repository has been presented including a detailed mapping of functional roles on technical roles and a complete presentation of the design rationales underlying the system design.

The Integrated System Design proposed in this chapter addresses generative fit on two layers: the theory is used as a kernel theory for the design product as well as the design process. First, the system design per se follows the theory of generative fit by implementing design directives proposed for achieving generative fit (cf. notes on the implementation of directives D4 through D9). In particular all design directives implementing generativity on the technology layer have been covered as this allows an extension of the overall system through integration of special-purpose applications to achieve generativity on the content layer. Additional design directives (D1, D2, and D3) can be implemented through specific subsystems. Second, through the open-ended, process-oriented nature of the design which allows the integration of special-purpose applications additional generative fit can be achieved through fine-tuning the blend of operational and generative features. The theory thus informs the design process to achieve the necessary blend of operational and generative system functions.

As has become obvious from the discussion of the architecture design and the chosen repository model, the definition of the data schema used to store data is a central issue. All subsystems to be integrated through the repository must agree on that data model and a compromise between the specific needs of each tool must be made. The design of the data schema directly influences the ability to integrate new subsystems and achieve data portability. As the data to be stored and manipulated in the repository is, due to the nature of the area of innovation management, per definition new and possibly unknown, the definition of the data schema represents a major challenge. The next chapter presents the Idea Ontology, a Semantic Web-based approach to solve this integration issue. Together with the Idea Ontology introduced in the next chapter, this chapter answers research question two.

Chapter 6

Idea Ontology

In Chapter 5 the need for the definition of a data schema to implement the concept of a shared innovation space through a central repository has been discussed. To implement the process-oriented, open-ended, central repository a shared understanding of what and how innovation relevant information is to be stored is necessary. Moreover, we argued (see Section 4.2) that such an approach should be grounded in the notion of generative capacity to support an open and extensible system. The definition of the shared data model is also necessary to allow the integration of various special-purpose tools which might span across organisational boundaries as argued by the platform perspective on open innovation (Section 5.1). To address these challenges this chapter proposes a Semantic Web-based approach using an ontology. The goal of the ontology-based approach is also to achieve rejuvenation through open development standards and easy upgrade paths (Avital/Te'eni, 2009). In the course of this chapter the analysis, design, and evaluation of the *Idea Ontology* is presented. A prototype system based on the Idea Ontology will be presented later in this work (Chapter 7). Together with system design developed in Chapter 5 the Idea Ontology answers RQ2.

This chapter is organised as follows. First, we give an introduction to Semantic Web and ontologies (Sections 6.1 and 6.2). Followed by a detailed analysis of data model challenges (Section 6.3) the chapter introduces the design of the Idea Ontology (Section 6.4). Section 6.5 presents an evaluation of the Idea Ontology to demonstrate the advantages of semantic reasoning followed by a discussion of limitations (Section 6.6) and a conclusion (Section 6.7).

6.1 Ontology Foundations

Ontologies are logical tools to support knowledge representation and retrieval. They can support innovation management by providing a structured representation of innovation related information such as ideas, ratings, and comments and thus establishing a unified vocabulary that can be shared across tools and organisations. The following section introduces ontologies and their potential in service innovation. In order to ensure a common understanding of the characteristic elements of an ontology, the most important definitions, principals, and classification of ontologies are introduced.

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Ontologies are widely used for natural language processing, knowledge management, and the Semantic Web. Various definitions of ontologies can be found in the area of information science. The most widely cited is that of Gruber (1993, 199):

> "An ontology is an explicit specification of a conceptualization."

In this context, a *conceptualisation* refers to an abstract model of how people think about things in the world, which is usually restricted to a particular subject area (Uschold/Gruninger, 2004). An *explicit specification* means that the concepts and relationships in the abstract model are given explicit names and definitions. A very similar definition is given by Borst (1997, 12):

> "An ontology is a formal specification of a shared conceptualization."

Formal means that the abstract meaning is encoded in a language in which formal properties are well understood. This usually refers to some logic-based languages. Finally, *shared* implies that the main purpose of an ontology is to be used and re-used across different applications and communities. The terms *explicit* (Gruber) and *formal* (Borst) refer to a declarative representation of the world of interest in which the most crucial terms are completely defined for mutual understanding (Fensel, 2003; Mizoguchi, 2003; Uschold, 1996).

The logical theory is composed of vocabulary, or concepts, to describe the things of interest. Concepts/vocabulary are used as building blocks of an information processing system (Mizoguchi, 2003). The vocabulary of an ontology is typically contained in a taxonomy which already holds classes, simple relations, and axioms (Mizoguchi, 2003; Krcmar, 2009). The role of an ontology is to provide vocabulary for metadata description with computer-understandable semantics. Thus, ontologies' aim is to establish a shared understanding between parties and make the metadata interoperable.

Things are represented in an ontology as *classes* (also called *concepts*) and are typically arranged in a taxonomy of classes and subclasses. Classes are typically associated with various *properties* (or called *roles*) that describe features or attributes of the class. Concrete instances of a class are *individuals.* Together with an ontology, instances constitute a knowledge base (Uschold/Gruninger, 2004).

Ontologies can be classified anywhere on a continuum ranging between a highly specific application ontology to a most general representation ontology, depending on the usage scenario that the ontology is intended for. For the application in the business context two well-known ontologies are the *Enterprise Ontology* (Uschold et al., 1998) and the *Toronto Virtual Enterprise* (Fox, 1992). They aim at capturing and analysing the key aspects of an enterprise and thus help to communicate, integrate, and represent the various aspects of an enterprise (Bullinger, 2008). Possibly the most important general ontology is *Dublin Core*. The Dublin Core Metadata Element Set, Version 1.1,[1] is a vocabulary of fifteen properties for use in resource description and is maintained by the Dublin Core Metadata Initiative.[2] Dublin Core assigns fixed semantics to properties related to the description

[1] `http://dublincore.org/documents/dces/` (last accessed 2010-10-26)
[2] `http://dublincore.org/` (last accessed 2010-10-26)

Entities of Dublin Core	
Title:	A name given to the resource.
Creator:	An entity primarily responsible for making the resource.
Subject:	The topic of the resource.
Description:	An account of the resource.
Date:	A point or period of time associated with an event in the life-cycle of the resource.
Type:	The nature or genre of the resource.
Format:	The file format, physical medium, or dimensions of the resource.
Identifier:	An unambiguous reference to the resource within a given context.

Table 6.1: *Exemplary entities of Dublin Core (adapted from* `http://dublincore.org/documents/dces/`*, last accessed 2010-10-26).*

of resources and provides the possibility to link to several documents. Table 6.1 provides some exemplary entities of Dublin Core. Due to its simplicity Dublin Core is popular for cataloguing and discovering resources (Krcmar, 2009).

6.2 Classification of Ontologies

As the examples of enterprise ontologies and Dublin Core illustrated, there exist numerous ontologies that differ according to their degree of expressiveness and intended type of application. To structure different ontologies they can be classified by the subject matter for which the ontology has been developed and can be distinguished by their degree of specialisation. Figure 6.1 displays the classification of ontologies proposed by Guarino (1998).

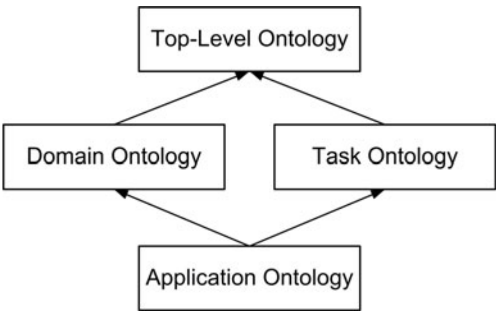


Figure 6.1: *Ontology classification (adapted from Guarino, 1998).*

Top-Level ontology (also upper or generic ontology) - describes general knowledge such as time and space.

Domain ontology - captures domain knowledge in a generic way. For example, it describes a domain such as medicine, enterprises, or trade goods.

Task ontology - these ontologies describe how a specific task is performed, for example, the assembly of certain parts to form a larger unit.

Application ontology - have been developed for a specific application, for example, to manage services. They contain concepts that depend on both, a particular task and a particular domain.

The Idea Ontology introduced in this work is an application ontology for IT supported innovation management for service ecosystems. Consequently, it describes concepts that depend on the general task of "innovation management" as well as concepts that depend on the domain of "service ecosystems" and, more generally, "services."

6.3 Detail Analysis

This section presents a detailed analysis to define the scope and content of the Idea Ontology. We first study the challenges that arise as a result of recent trends in innovation management (Section 6.3.1). We then present an empirical analysis of innovation portals (Section 6.3.2). To define the scope of such an ontology in more detail, we propose a set of competency questions that such an ontology should be able to answer (Section 6.3.3). The section then motivates the use of an ontology to meet these challenges (Section 6.3.4) and analyses related work (Section 6.3.5).

6.3.1 Analysis of Innovation Management Domain

What is an idea? How does it relate to an innovation? While people may have an intuitive understanding of what these terms mean, there is no accepted, precise, and formal definition for the concept of an idea. As holistic innovation management and, in particular, the concept of open innovation gains traction, it becomes increasingly important to close this gap: a commonly agreed concept of an idea would support exchanging and analysing ideas across different idea platforms and innovation tools, and hence be the basis to realise the vision of open innovation (cf. Section 3.5).

The Oxford English Dictionary defines an *idea* as: "1 a thought or suggestion about a possible course of action. 2 a mental impression. 3 a belief." An *innovation* is defined as: "1 the action or process of innovating. 2 a new method, idea, product, etc." Rogers defines an innovation as "an idea, practice or object that is perceived as new by an individual or other unit of adoption" (Rogers, 2003, 36). This definition indicates that an innovation is more than an idea. To become an innovation, an idea has to be adopted. This concept is further developed by linking an idea or invention not only to adoption but to the concept of commercialisation. Thus, Porter defines innovation as "a new way of doing things (termed invention by some authors) that is *commercialized*" (Porter, 1990, 780). A precise definition of the meaning of the term "innovation" has been contentious and problematical and terms are often used loosely and interchangeably (Storey, 2000). However, there seems to be agreement on a general distinction between "invention" and "innovation" (Storey, 2000). Bullinger (2008, 14) defines an *innovative idea* as "the more or less vague perception of a combination of purpose and means, qualitatively different from existing forms." She thus claims it to mark the starting point of an innovation activity. As innovative ideas form the basis of an innovation, idea collection and development is considered one of the first steps in most innovation process models (e.g., Cooper, 1990; Tidd/Bessant/Pavitt, 2009; Wheelwright/Clark, 1992).

In the context of providing a tool to support the management of innovation processes, these definitions are not adequate because they do not specify 1. what information should be conveyed in an idea and 2. which methods or operations are applied to ideas. As Krcmar/Astana (1986, 3) put it: “To be communicateable an idea also has to be formulated.” Hence, for the purpose of developing a semantic representation of the concept of an idea in innovation management applications, we informally define an *idea* as:

> An explicit description of an invention or problem solution with the intention of implementation as a new or improved product, service, or process within an organisation.

This central concept of an idea, which we term *Core Idea*, can be supplemented with various concepts that relate to feasibility and marketability, i.e., commercialisation. Many of these concepts are used in the selection of tools that have been developed to support the different phases of idea generation and idea evaluation (van Gundy, 1988).

6.3.2 Empirical Analysis of Innovation Portals

As has been introduced in Section 3.5 a recent trend in innovation management is the implementation of openly accessible idea Web portals as one form to support online innovation communities. We analysed more than 30 publicly available idea portals with between 164 ideas (SAPiens, an innovation community in Germany for SAP) and over 83.000[3] ideas (Starbucks) with regards to how they describe and manage ideas. Table 6.2 shows a selection of the results.

Based on this analysis, we identified the following aspects to be included in an ontology for innovation management:

Comments and discussions help to identify shortcomings within the original idea and develop it towards the users' needs (Franke/Shah, 2003; Piller/Walcher, 2006). Thus, open and interactive forums are key requirements within company-internal innovation management, e.g., employee suggestion systems, as well as in idea development Web portals (Fairbank/Williams, 2001; Fairbank/Spangler/Williams, 2003).

Ratings are widely used to estimate user acceptance of ideas and are a key metric for idea selection (van Gundy, 1988). Within innovation management, many different rating

[3] Number of ideas as of June 2010

Name	*Comment*	*Rating*	*Classes*	*Tags*	*Attachment*	*Status Model*
Atizo (CH)[4]	Yes	Thumb up	-	Yes	Yes	Open, In Evaluation
Crowdspirit (FR)[4]	Yes	Thumb up/down	Single	Yes	Yes	Incubator (Ongoing, Evaluated, Rejected), Elevator, Idea in Market, Idea in Action
Dell (US)[4]	Yes	Thumb up/down	Multiple	No	Yes	Already Offered, Implemented, In Progress, Partially Implemented, Reviewed, Under Review
ErfinderProfi (DE)[4]	Yes	Scale 1 to 10	Single	Yes	Yes	-
Fellowforce (NL)[4]	No	No	Multiple	No	Yes	-
Google Idea (US)[4]	No	Like/Don't like	Single	No	No	New, Answered
IdeaJam (US)[4]	Yes	Thumb up/down	Single	Yes	No	Open, In Progress, Complete, Rejected, Withdrawn
Incuby (US)[4]	Yes	5-Star	Single	Yes	Yes	With patent (Pending, Provisional, Full, Pat.-No.), Without Patent, Concept or Idea
Innocentive (US)[4]	No	No	Multiple	No	Yes	Individually specifiable by the innovation seeker
Ninesigma (US)[4]	No	No	Multiple	No	Yes	New, Open, Closing Soon, Extension Available
Oracle Mix (US)[4]	Yes	Thumb up	Multiple	Yes	No	n/a
Salesforce (US)[4]	Yes	Thumb up	Multiple	No	Yes	Coming in *release*, Delivered in *release*, Existing Feature, Partially Implemented, Partner Solution Available, Polling Promo, Under Consideration
SAP Idea Place (DE)[4]	Yes	Thumb ub/down	Single	Yes	No	Submitted, Under Review, For Future Consideration, Already Offered, Coming Soon, Implemented, Archived
SAPiens (DE)[4]	Yes	Thumb ub/down	-	Yes	Yes	New idea, Under review
Starbucks (US)[4]	Yes	Thumb up	Single	No	Yes	New, Under Review, Reviewed, Coming soon, Launched
Ubuntu (US)[4]	Yes	Thumb up/ Don't care/ Thumb down	Single	Yes	Yes	New, Awaiting moderation, Not an idea, Already implemented, Duplicate, In development for *release*, Implemented in *release*

Table 6.2: *Analysis of a sample of publicly available innovation portals.*

[4] `http://www.atizo.com/`, `http://www.crowdspirit.com/`, `http://www.dellideastorm.com/`, `http://www.erfinderprofi.de/`, `http://www.fellowforce.com/`, `http://productideas.appspot.com/`, `http://ideajam.net/`, `http://www.incuby.com/`, `http://www.innocentive.com/`, `http://www.ninesigma.com/`, `http://mix.oracle.com/`, `http://ideas.salesforce.com/`, `http://ideas.sap.com/` `http://www.sapiens.info/` `http://mystarbucksidea.force.com/`, `http://brainstorm.ubuntu.com/` (last accessed 2010-10-26)

mechanisms are generally applied. The methods differ substantially in (a) the rating subject (who is allowed to rate), (b) the rating object (what aspects are rated), and (c) the rating scale. Note that Table 6.2 alone names six different rating scales.

Grouping and clustering methods help to keep track of idea submissions, especially within large idea portfolios. The two main approaches to group ideas are hierarchical classification systems and tagging mechanisms. The analysis shows that the two methods are frequently used in parallel. The categorisation schemes are usually highly domain-specific and differ in aspects including granularity, depth, and multi-selectability.

Status: In addition to content-related classification, organisational aspects are often applied to arrange the idea portfolio. Many idea portals assign an explicit development state to each idea, e.g., "ongoing," "evaluated," or "rejected." This finding strongly correlates with the process-oriented design of the unifying framework. Furthermore, patents and trademarks are widely used to protect innovations or to exploit them commercially (e.g., via licensing contracts). Thus, patent and copyright information are highly important within idea management.

6.3.3 Competency Questions

To further determine the scope of the ontology, we developed a list of exemplary competency questions that a knowledge base developed using the ontology should be able to answer. The use of competency questions to define the scope during ontology development is recommended by Gruninger/Fox (1995). The questions have been prepared from the perspective of an innovation manager working with a large pool of ideas. The competency questions have been developed and subsequently validated through three interviews with key users experienced in innovation management. The interviews were conducted in January 2010. Each interview was between 30 and 40 minutes in length. At the same time these questions also served as test cases for the evaluation of the Idea Ontology (Section 6.5).

- Which ideas are in the repository?
- For which categories have ideas been submitted?
- Which tags have been used to classify ideas?
- Which ideas have already been implemented?
- Which ideas have at least three ratings?
- Which ideas have at least two or more ratings as well as at least one realisation?
- Who are the most valuable community members by assessing at least three ideas?
- Which ideas already have a business plan attached (i.e., have an attached document with the topic "business plan" to indicate feasibility)?

6.3.4 Motivation for an Idea Ontology

Several benefits can be expected from the use of an ontology, including a shared and common understanding, providing structure to poorly structured or unstructured information, realising management support and interdisciplinary communication as a result of structuring information, and allowing the analysis and comparison of the information represented beyond operational data (Noy/McGuinness, 2001; Fensel, 2002; Fensel, 2003; Hüsemann/Vossen, 2005). Menzies (1999) and Gruninger/Lee (2002) mention, among others, four additional benefits of ontologies:

- Interoperability - a mapping between the concepts of two interfacing applications can be created to allow the components to interact.
- Browsing and searching - using the metaknowlege within an ontology can be used by an intelligent search engine to process queries.
- Re-use - ontologies can be re-used across organisations and across projects.
- Structuring - using the conceptualisations in ontologies can help in structuring the knowledge in a new domain and thus speed up the development of new application systems.

Uschold/Gruninger (1996; 2004) stress in particular the seamless connectivity that can be achieved between ontology-based software agents and IT systems. Furthermore, Parastatidis/Viegas/Hey (2009) call for a push of semantic technologies in general but by researchers in particular. In addition to these generic benefits of representing information with defined ontologies, other benefits particularly important in the area of representing ideas and innovation management can be expected. Bullinger (2008) elaborates the potential application and benefits of deploying ontologies in business fields:

- Ontologies help to overcome language barriers in functional organisations. Different language and knowledge cultures in areas such as supply, production, or sales often hinder communication across an organisation. These cultures can be translated by an ontology
- Ontologies allow the internal integration of information systems.
- Ontologies enable semantic access to the knowledge in the World Wide Web. They are particularly used in B2B markets, for example, in the area of e-procurement and automatic interactions in general.

The semantics of an organisation's specific working context are captured by its local or private ontology, which serves the purposes of the particular organisation (Ning et al., 2006). Thus, a common language based on an ontology provides a common idea data interchange format to support interoperability and to improve cross-enterprise collaboration. With that regard, an ontology can help focus on content (Guarino/Musen, 2005). An ontology approach is per definition very flexible as the ontology used by a system can be changed at runtime. Through their XML-based syntax ontologies are particularly suited to address the technical aspects of system integration described in the unifying framework. In the particular area of tool-supported innovation management Schwabe (1995) names semantic representation of group support system results as a key requirement.

Today, many idea portals on the Web are restricted to capabilities like tagging and ordinal ratings as the basis for idea analysis. However, this research argues that more powerful tools and methods in idea portals as the one developed in this work cannot reveal their full potential until agreement is reached on the basic concepts of an idea. The use of semantic techniques brings with it the possibility to improve end-user efficiency by means of automated processing, and to cope with advanced analytical processing of idea metadata through reasoning. Innovation managers could profit from better structured information, integration and data exchange across tools and platforms, and additional semantic reasoning that allows them to analyse ideas based on related concepts.

In summary, the main benefits of using an ontology approach for idea management are the ability to achieve interoperability and technical integration between tools resulting in a better support of the idea life-cycle from idea generation, idea evaluation, to idea implementation.

6.3.5 Related Research

Although several other research projects currently deal with aspects of idea and innovation management, none of them explicitly aims at creating a common idea ontology for the purpose of achieving interoperability across innovation tools. Ning et al. (2006), for example, describe the system architecture of an innovation system that combines ontology, inference, and mediation technologies to facilitate the distributed collection and development of ideas. Their system is based on metadata harvesting and RDF access technologies. It relies on semantic technologies to allow for integration of idea development tools. However, the article does not give details of the concepts used in the proposed ontology and the ontology is not publicly available.

The innovation ontology developed by Bullinger (2008), called *OntoGate*, aims at modelling the idea assessment and selection on a company-specific level. The ontology is deduced from empirical research and offers a means to structure a company's understanding of the innovation process, in particular the inputs, outputs, participants, and assessment perspectives. For example, different inputs into the innovation process have been developed such as *internal input* and *external input* which can further be broken up in *continuous internal input* and *discontinuous internal input*, input by *employees* and input by *executives* and so on. Thus, it gives an organisation a better understanding of how the overall innovation process can be structured and how ideas can be systematically developed. In contrast to the ontology presented here, it does not provide a data model for representing individual ideas. Regarding the assessment of ideas, the largest module of the OntoGate ontology, three perspectives along which an idea or concept can be evaluated are suggested and subsequently developed: market, strategy, and technology. The resulting ontology, OntoGate, is classified as a *domain ontology* (Bullinger, 2008) as it represents the terms used to describe idea assessment and selection during the early stages of the innovation process in companies.

While the Idea Ontology, which can be classified as an *application ontology*, provides a technical means to represent complex idea evaluations along various concepts, OntoGate provides the necessary domain knowledge to decide which perspectives and criteria should actually be used for the assessment. Thus, OntoGate complements this ontology with additional valuable domain knowledge to setup and customise a system based on the Idea Ontology to support and structure a given innovation scenario.

The specific contribution of this work compared to Bullinger's is the description of a technical architecture in which the ontology can be applied. The aim of the Idea Ontology is to offer a common language for idea storage and exchange for the purpose of achieving interoperability across innovation tools. Through reusing existing ontologies it is possible to achieve interoperability not only among specialised innovation management tools but general applications as well such as social networking. The innovation ontology developed by Bullinger (2008) aims at modelling the idea assessment and selection rather than providing technical integration.

6.4 Ontology Design

This section introduces the Idea Ontology and gives a detailed explanation of the innovation and generic concepts it uses. We chose OWL for the development of our ontology and followed a generic ontology development approach (McGuinness/van Harmelen, 2005; Antoniou/van Harmelen, 2004; Noy/McGuinness, 2001; Guarino, 1997). Neither RDF nor RDFS is expressive enough to model complex structures like complex classes and relations carrying semantic expressions. As RDFS supports only classes and relations, it is capable of modelling sub-class concepts and relations, but only simple ones. In the evaluation section, this is illustrated with an example. We chose the development approach by (Noy/McGuinness, 2001) as it focuses in particular on the re-use of existing ontologies which is a desirable attribute of ontologies (Lonsdale et al., 2009; Bullinger, 2008). For the modelling itself we used Protégé.[5] The namespaces used in the ontology are summarised in Table 6.3.

Ontology	*Prefix*	*Short Description*
Idea Ontology	`im`	The ontology for innovation management introduced in this chapter
RDF	`rdf`	Resource Description Framework
Dublin Core	`dc`	The Dublin Core for metadata about resources
FOAF	`foaf`	The Friend of a Friend ontology for describing agents and their relationships
SIOC	`sioc`	An ontology for (online) communities
SKOS	`skos`	An ontology for knowledge organisation
Tagging Ontology	`tags`	A simple tagging ontology
Rating Ontology	`r`	A rating ontology

Table 6.3: *Referenced ontologies.*

Figure 6.2 depicts the ontology's main modules. Modularity is a key requirement for large ontologies, as it facilitates reusability, maintainability, and evolution (Gómez-Pérez/ Benjamins, 1999). Stuckenschmidt/Klein (2007) name the following reasons for modular design of ontologies: 1. handling of ontologies in distributed environments like the Semantic Web, 2. management of large ontologies, and 3. efficient reasoning. Hence, a central design goal was to create a highly modular ontology. We achieved this by incorporating established ontology specifications to represent the more general metadata concepts that are associated with an idea (Bojrs et al., 2008). We therefore evaluated existing ontologies with regard to their suitability to be re-used in the Idea Ontology. In addition, we chose

[5] `http://protege.stanford.edu/` (last accessed 2010-10-26)

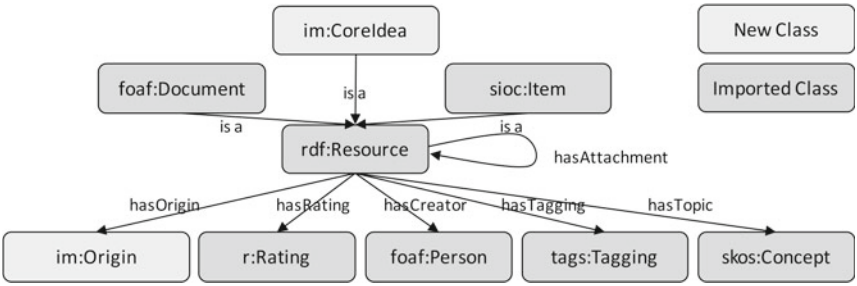


Figure 6.2: *Overview of the Idea Ontology.*

a hierarchical design that groups the three classes `im:CoreIdea`, `foaf:Document`, and `sioc:Item` under a super class `rdf:Resource`. Thus, it is possible to specify relations to various common meta-information which are then re-used for all innovation-related resources. Specifically, every `rdf:Resource` has the following generic relations:

- `im:Origin`: the application from which the resource originates;
- `r:Rating`: a rating mechanism that allows rating of the resource;
- `foaf:Person`: the creator of the resource;
- `tags:Tagging`: folksonomy tagging of the resource;
- `skos:Concept`: definition of a subject matter of the resources that allows grouping of ideas;
- `rdf:Resource`: through the `hasAttachment` relationship, innovation-related objects can be linked to each other.

However, it is important to note that an `im:CoreIdea` is the central object that defines an innovation project and for that purpose draws on other innovation resources such as documents and community discussions.

6.4.1 Innovation Concepts

Core Idea: To achieve a generic and versatile representation of ideas, we chose a hierarchical design with three layers of textual descriptions for an `im:CoreIdea`: `dc:title`, `im:abstract`, and `im:description`. All three represent a textual description of the idea but vary in length and detail. Thus, the ontology is able to support very simple tools such as electronic brainstorming, where an idea usually consists of no more than one sentence, up to more advanced tools that allow longer descriptions. It is also possible to extend the description with resources such as images, screenshots, or process diagrams: they can be attached as `foaf:Documents` using the `hasAttachment` relationship. Furthermore, every `im:CoreIdea` has an associated creation date `dc:Date` and a version number to allow tracking of different instances of the same idea by means of the `isNewVersionOf` relationship. An idea can also have a relationship with `sioc:Forum` (using `hasForum`) and `im:IdeaRealization` (using `hasRealization`) which we describe in the sections below. Figure 6.3 shows the complete `im:CoreIdea` class and its relationships.

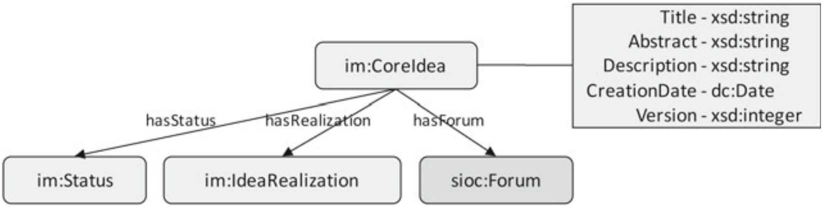


Figure 6.3: *The Core Idea element of the Idea Ontology.*

```
<#idea123> a im:CoreIdea ;
        dc:Title "Calculate environmental sustainability based on
                        bill of materials." ;
        im:hasForum <#forum idea123> .
<#forum idea123> a sioc:Forum .
<http://en.wikipedia.org/wiki/Market> a skos:Concept ;
        skos:prefLabel "Market"@en .
<http://en.wikipedia.org/wiki/Customer> a skos:Concept ;
        skos:prefLabel "Customer"@en .
<#item101> a sioc:Item ;
        sioc:hasContainer <#forum idea123> ;
        im:hasTopic <http://en.wikipedia.org/wiki/Market> ;
        sioc:content "Automotive industries" .
<#item102> a sioc:Item ;
        sioc:hasContainer <#forum idea123> ;
        im:hasTopic <http://en.wikipedia.org/wiki/Customer> ;
        sioc:content "Engineering departments of auto mobile
                        manufacturers" .
```

Listing 6.1: *Representation of idea submission forms.*

When describing an idea, aspects related to the respective business context are relevant. They may be used to, for example, assess the feasibility of an idea. Examples include a reference to the market, in which an idea can be commercialised, or potential customers and competitors. To model these descriptive attributes of an idea, we re-used the established Enterprise Ontology (Uschold et al., 1998). This ontology defines the semantic meaning of terms such as market, customer, competitor, supplier etc. Technically, we model these descriptive arguments as `sioc:Item`s that are attached to an idea and linked to a `skos:Concept` through the `hasTopic` relationship that defines the semantic meaning of the argument. As `sioc:Item`s are modelled as `rdf:Resource`s, it is possible to assign a rating to them. This makes it possible, for example, to state that a certain `sioc:Item` instance contains a text related to the *market* concept (through `hasTopic`) and then rate this specific attribute using a five star rating. Listing 6.1[6] illustrates how the combination of `im:CoreIdea`, `sioc:Item`, and `skos:Concept` can be used to represent detailed idea submission forms in a semantically enriched way. Furthermore, a `foaf:Document` linked to an idea using `hasAttachment` may contain a business plan, refer to a market analysis, or a relevant patent. Together with expert ratings an innovation manager would be able to evaluate the quality of an idea (cf. the last competency question from Section 6.3.3). These artefacts can be of great help once the idea is realised.

[6]Code samples use N3 notation `http://www.w3.org/DesignIssues/Notation3` (last accessed 2010-10-26).

Discussions and Collaboration using SIOC: Discussions and collaboration, both within and across organisations, are an important means for developing ideas (see, for example, Ahuja, 2000; Gemunden/Salomo/Holzle, 2007). With increasing adoption of open innovation processes and the integration of external actors into the innovation process, the ability to systematically support discussions and collaboration becomes a key functionality (Chesbrough, 2006b; West/Lakhani, 2008). Consequently, the ability to support comments has been added to the ontology.

Semantically-Interlinked Online Communities (SIOC) is an established ontology for integrating online community information (Bojãrs/Breslin, 2007). SIOC can be used to represent community information such as blog, wiki, and forum posts. In the Idea Ontology, every `im:CoreIdea` can be linked to one or more `sioc:Forum`s using a `hasForum` relationship that provides a container for `sioc:Item`s related to the discussion of that idea. Furthermore, SIOC can be applied to model access rights to individual resources.

Status: In order to track an idea's progression throughout a submission, evaluation, and implementation process, it is necessary to track the status of an idea. The `im:Status` class offers this functionality: through a `dc:Title` a set of status individuals (i.e., instances) can be created depending on the innovation context. For example, status individuals could be "none," "under review," "in process," "implemented," "already offered" or others depending on the area of application and the innovation process in place. More formally, the output states proposed by Bullinger (2008) could be used: "stop," "hold," and "invest." These individuals are then associated with an idea via the `hasState` relationship. In this way, the ontology can easily be integrated into existing processes and evaluation structures.

Idea Realisation: To support the full innovation life-cycle and to allow for incremental innovations of existing products and services the link between ideas and their resulting realisations must be preserved. In general, this is necessary to support the process-oriented nature of the unifying framework. Moreover, the back-link from a realisation to the original idea supports the application of various performance measures. For example, it would be possible to identify authors of highly successful ideas. To achieve this tracking across the life-cycle our ontology contains an `im:IdeaRalization` class which is linked to an `im:CoreIdea` by means of the `hasRealization` object property. The `im:IdeaRealization` class is a place holder for whatever is an appropriate means of representing an idea's realisation. In a product environment, this may be a product number. In a software-as-a-service environment, the idea realisation could link to a description of a Web service, for example, using WSDL (Christensen et al., 2001) or USDL (Cardoso et al., 2010).

6.4.2 Generic Concepts

User: Friend of a Friend (FOAF) is an established RDF/OWL-based ontology for describing persons, their activities, and their relations to other people and objects (Brickley/Miller, 2007). Due to its de-facto standard for representing information about people and its simple design, we chose FOAF for representing all person-related information in the Idea Ontology. Specifically, links to a `foaf:Person` are maintained for all resources as `hasCreator`, and for `im:Rating` and `tag:Tagging` as `ratedBy` and `taggedBy`, respectively.

Tagging: Tags are keywords or terms associated with or assigned to a piece of information - in our case innovation resources (Krcmar, 2009). Due to their popularity in online communities and apparent benefits for information browsing (Mathes, 2004; Golder/Huberman, 2005), a tagging concept has been added to the ontology. Tag Ontology is an established and simple ontology for representing tagging information, which is also used by SIOC (Newman, 2005). Tag Ontology represents tags as tuples of $< tagger, tag, resource, date >$. In the Idea Ontology, tags can be associated with all innovation resources by means of the `hasTagging` relationship. While the tagging approach is rather generic, the opportunity of changing the ontology at runtime and thus allowing an adaptation of an ontology-based system to a given scenario's requirements, offsets the benefits of a more specific tagging approach.

Grouping: The Simple Knowledge Organisation System (SKOS) is a W3C Recommendation of a common data model for sharing and linking knowledge organisation systems such as thesauri, taxonomies, and classification schemes (Miles/Bechhofer, 2008). SKOS allows the definition of "concepts" that are identified using URIs and labelled with lexical strings in one or more natural languages. Furthermore, concepts can be linked to other concepts using semantic relations such as `skos:broader`, `skos:narrower`, and `skos:related`. This allows us to build taxonomies and semantic relationships between the various `rdf:Resources` that are associated with the concepts using the `hasTopic` relationship. This association with semantic concepts is used in two ways. First, a `im:CoreIdea` can be associated with a topic to indicate which subject area an idea belongs to (e.g., an idea related to the automotive sector). Second, it can be used in association with comments attached to an idea (`sioc:Items`) to support a structured idea assessment along predefined perspectives. For example, the perspectives *market*, *strategy*, and *technology* proposed in the ontology by Bullinger (2008) could be used for idea assessment. Additional semantic concepts can be added at runtime which allows the extension and customisation of an ontology-based system.

Tracking the Origin of Contributions: As one of the main goals, the Idea Ontology fosters interoperability between various innovation management tools. Therefore, it is necessary to keep track of the application from which a given resource originates. The `im:Origin` class can be used for this purpose. An `im:Origin` contains a `dc:Source` and `dc:Title` attribute. In this way it can be stated that an idea originates, e.g., from a brainstorming tool, an idea portal on the Web, or another application.

Rating: A rating is used to associate values of appraisal for a resource. In the innovation domain, rating is of utmost importance as it is a necessary step for idea evaluation and selection (van Gundy, 1988). A great variety of idea evaluation and selection methods has been proposed (e.g., van Gundy, 1988) and new concepts like prediction markets are investigated for their suitability for idea evaluation (Stathel et al., 2008; Stathel/van Dinther/Schönfeld, 2009). Hence, the rating concept is required to be configurable with respect to the rating method and the range of values.

To accommodate these requirements, we extend the rating ontology proposed bi Longo/ Sciuto (2007) to support different kinds of ratings (Figure 6.4). Based on this ontology, an `r:Rating` is a 4-ary relationship as follows: its rating value is expressed as some numerical `r:value`, the interpretation of which is application-dependent. The `r:Rating` refers to the resource that is rated. Notice that ratings are not restricted to ideas, but can refer also to documents or comments. A `foaf:Agent` refers to the person who expresses an appraisal for the rated resource. Note that we chose `foaf:Agent` instead of `foaf:Person` because ratings can also be expressed by software agents. The `r:RatingCollector` is a source that is used to collect ratings. The domain of values generated by this source is either defined as an enumeration of values or by an interval of numeric values (see Longo/Sciuto, 2007 for examples). The `r:RatingKind` is used to distinguish different aspects of the rated resource. Possible instances may be an `OverallRating` or a `UsabilityRating`.

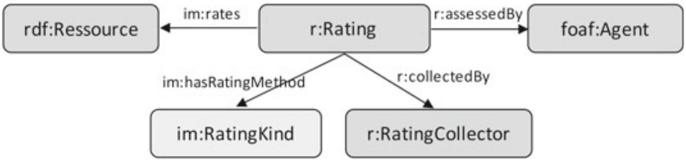


Figure 6.4: *The Idea Ontology rating module.*

6.4.3 Summary

This section presented the design of the Idea Ontology. The innovation centric concepts of an idea (Core Idea, discussion and collaboration, status, and idea realisation) have been introduced as well as the generic aspects related to all innovation relevant resources (user, tagging, grouping, origin tracking, and rating). Additional technical details of the Idea Ontology can be found in the complete technical specification (Appendix A).

6.5 Evaluation

The two major paradigms in information systems research are behavioural science and design science (Hevner et al., 2004). Ontologies are considered *engineering artefacts* (Guarino/Giaretta, 1995) and thus the design of the Idea Ontology clearly falls in the design science category. Consequently, the question on how to evaluate the designed artefact, i.e., the ontology, arises. The evaluation of ontologies is an emerging field and at present a deep core of preliminary ideas and guidelines for the evaluation of ontologies is missing. However, Gómez-Pérez (2004) suggests, based on previous works, to evaluate ontologies using the criteria consistency, completeness, conciseness, expandability, and sensitiveness. As has been discussed in Section 2.2.5 there are numerous possibilities how to evaluate an artefact: analytical, case studies, controlled experiments, field studies, and simulations (Hevner et al., 2004; Siau/Rossi, 2010). For the Idea Ontology developed, the argument for the utility, quality, and efficacy of the chosen approach is based on four basic evaluation methods: scenario, prototypical implementation, informed argument, and architectural analysis.

Scenario The rationale behind using scenarios for evaluation of design artefacts in information systems is that scenarios can demonstrate the utility of an artefact. To this end, the Idea Ontology is applied to a scenario derived from a large research project (cf. Section 7.2). This scenario points out clearly the necessity of a structured innovation process utilising an innovation ontology.

Prototypical Implementation As a proof-of-concept, the ontology forms the basis for data storage and communication in the TEXO Innovation Repository prototype (Chapter 7). Artefact instantiation in general and a prototypical implementation in particular demonstrate the feasibility of the proposed artefact. The construction of the prototype that implements the unifying framework by using an ontology-based approach as the integrative data schema shows that such a system can be constructed and be supported by using already existing artefacts. Thus, the prototype implementation provides proof by construction (Nunamaker/Chen/Purdin, 1991; Hevner et al., 2004). The prototype implementation demonstrates in particular how the aim of an open-ended platform that is able to integrate a variety of external special-purpose tools has been realised through the use of the Idea Ontology. For that purpose, Section 7.2.5 provides a table for mapping between the data fields used in a set of special-purpose tools and Idea Ontology concepts.

Informed Argument The basic concept of informed arguments is to use information from relevant related research to build an argument for the artefact. To this end, we derived the requirements for the Idea Ontology in Section 6.3, which contains an argumentation, why the approach is promising and useful.

Architectural Analysis In an architectural analysis one studies the fit of an artefact with the technical architecture of the overall information system. By referring to the unifying framework (Section 5.2) and the system design (Section 5.4) throughout the ontology design section the argument has been established that the technical representation of the Idea Ontology fits with the technical architecture and overall system design.

To determine whether the ontology contains enough information, i.e., its completeness, and to demonstrate advanced semantic reasoning functions, we evaluated our ontology against the set of competency questions proposed in Section 6.3.3. For that purpose, we designed test cases with sample data instances and modelled OWL DL query statements to answer the competency questions. In case of RDF and RDFS, queries are formulated with the SPARQL query language. For OWL-based ontologies as mentioned above, OWL DL queries are necessary. Thus, for example, to retrieve a list of all ideas stored in the ontology, the simple statement "`CoreIdea`" is sufficient. The reasoner will return all instances of the class `im:CoreIdea`. To answer more specific questions, more complex query statements are necessary. Table 6.4 presents a mapping of our set of competency questions to OWL DL queries. From the subsumption tests performed by the OWL DL reasoner derive concept satisfiability and consistency (Gómez-Pérez, 2004).

Other questions that leverage the semantic abilities of an ontology include, for example, Which ideas are related to environmental topics? or What ideas have an economic market analysis attached to them? These questions span several namespaces imported in the Idea Ontology (`im`, `r`, `skos`). Instead of writing complicated SQL statements as would be necessary for a system based on relational databases, in ontologies a reasoner will work to identify the result set of these questions.

Competency Question	*OWL DL Query*
Which ideas are in the repository?	`CoreIdea`
For which categories have ideas been submitted?	`isSubjectOf some CoreIdea`
Which tags have been used to classify ideas?	`Tagging and inv(hasTagging) min 1`
Which ideas have already been implemented?	`CoreIdea and hasRealization min 1`
Which ideas have at least three ratings?	`CoreIdea and hasRating min 3`
Which ideas have at least two or more ratings as well as at least one realisation?	`CoreIdea and hasRating min 2 and hasRealization min 1`
Who are the most valuable community members by assessing at least three ideas?	`Person and inv(assessedBy) min 3`
Which ideas already have a business plan attached (i.e., have an attached document with the topic 'business plan' to indicate feasibiliy)?	`CoreIdea and hasAttachment some (Document and hasTopic value http://en.wikipedia.org/wiki/ Business\_plan)`

Table 6.4: *Competency questions and matching OWL DL queries based on the Idea Ontology.*

As shown by the examples, using ontologies for structured knowledge representation offers several advantages in expressing relations, subclasses and dependencies between objects, as well as "easy" querying. For the proposed ontology, these concepts are necessary to model the sophisticated interdependencies and links in related ontologies like SKOS or SIOC. Using subclasses to describe concepts enables efficient inferencing and reasoning. The examples showed that the ontology's design is capable of returning a result set with adequate reasoning done by a reasoner like pellet[7] or racer.[8] This is a valuable advantage that would be hard to realise with a traditional database-oriented system. By means of the imported ontologies, it becomes possible to add whole new concepts to an idea via already existing ontologies to enrich the idea and, at the same time, keep the ontology consistent.

6.6 Interpretation of Results

It is important to note that the Idea Ontology is an enabling technology. It cannot substitute proper innovation management processes in the organisation or project at hand. Technical aspects such as repository management, content synchronisation and tracking also represent complementary issues. With regards to existing innovation management systems, the use of the Idea Ontology would translate to re-engineering the systems for the purpose of more flexible and extensible exchange of ideas between applications, teams, projects, and organisations. In the general context of so called extended enterprises (Browne/Hunt/Zhang, 1998), the time to realise synergy effects constantly gains importance.

[7] `http://clarkparsia.com/pellet/` (last accessed 2010-10-26)
[8] `http://www.sts.tu-harburg.de/~r.f.moeller/racer/` (last accessed 2010-10-26)

The design of the Idea Ontology has certain limitations. Although information from different research projects, interviews with key users experienced in innovation management, as well as an analysis of existing innovation communities and other innovation-related tools have been incorporated into the Idea Ontology, the scope might still be limited. The application of the Idea Ontology on an even broader scope, in other projects, and additional integration of innovation-relevant tools could further strengthen the confidence in the robustness of the ontology. Certain innovation scenarios or idea-related concepts might not be adequately covered by the ontology. However, the modular design allows the easy extension of the ontology. For example, the Idea Ontology has already been integrated into a larger service ontology as described by Oberle et al. (2009) or Ferrario/Guarino (2008). This supports the argument for a flexible modular design of the ontology. Furthermore, it indicates that the Idea Ontology can not only be used as a stand-alone ontology but can also be integrated into a larger system.

6.7 Summary

This chapter presented the analysis, design, and evaluation of the Idea Ontology. The chapter on the Integrated System Design (Chapter 5) argued that a common language is a key requirement for information sharing and to foster interoperability between tools. This chapter first presented a definition of the concept of an "idea." Second, based on the detailed analysis of the innovation management domain, the design of the OWL-based Idea Ontology has been presented. Its primary goal is to facilitate interoperability between the various tools necessary to support the full life-cycle of an idea in an open innovation environment and thus to facilitate the implementation of the system design presented in Section 5.4. In addition to the interoperability issue the ontology also solves the data portability requirement of generativity on the technology layer presented in Section 4.5. The ontology provides a consistent and semantically enriched method to represent the information in the "fuzzy front-end" of innovation (Menor/Tatikonda/Sampson, 2002; Bullinger, 2008). Furthermore, the use of semantic techniques enables advanced management functions like semantic reasoning and automatic analysis. The design and development of the ontology follows the guidelines for design science research (Section 2.2.1.3). For instance, problem relevance stems from the fact that the representation of ideas in innovation management is a problem domain with limited structure because ideas are, by their very nature, new and mostly not well understood. Furthermore, current development with an emerging interest in open innovation processes makes collaboration and information exchange between organisations important. The ontology has been developed by performing a thorough analysis of the requirements resulting from the unifying framework and system design.

Particular emphasis has been given to the support for various community-related features such as commenting, tagging, and flexible rating mechanisms which are necessary to support the platform perspective on open innovation (Section 5.1). The Idea Ontology can act as an enabler for open innovation processes as it provides a technical basis by means of which ideas can be generated systematically, refined, and evaluated across a wide set of tools and actors within or even across communities. The specific contribution of the Idea Ontology is the description of the technical architecture in which such an ontology-based approach is applied. Together with the system design presented in the previous chapter

(Chapter 5) the Idea Ontology answers RQ2. Furthermore, the Idea Ontology serves as central data structure and technology enabler for the prototype development in the next chapter.

Idea Ontology as a Standard In addition to scientific publications (Riedl et al., 2009d; Riedl et al., 2009c) the Idea Ontology developed in this work has been published online under `http://www.ideaontology.org/` with the aim of establishing the Idea Ontology as a standard representation for innovation related information. As is common for ontologies (cf. SKOS, SIOC, FOAF) the Idea Ontology has been published online as an RDF/OWL-based ontology under the Creative Commons[9] license. The online publication of the ontology is accompanied by a complete specification documentation in HTLM (also under Creative Commons). The HTML specification documentation follows a linked data model (Berners-Lee, 2006): every term of the ontology (i.e., all classes, object properties, and data properties) are accessible via an URL. Thus, the specification is easily navigable and terms can be accessed directly. The complete specification of the Idea Ontology can be found in Appendix A.

[9] `http://www.creativecommons.org/` (last accessed 2010-10-26)

Chapter 7

Prototype Development

The Idea Ontology presented in the previous chapter provides the central data structure to solve the integration challenge of the unifying framework. Thus, it implements a core aspect of the Integrated System Design (Chapter 5). Together, the two chapters answered the second research question. But, how can the system design be transformed into a concrete implementation? Furthermore, what can we learn from the implementation and evaluation of such a system? To answer the third research question, this chapter presents the system implementation of the TEXO Innovation Repository. Only through the instantiation of the concrete IT artefact can we demonstrate the feasibility of the system design and reason about the utility such an application would have. Consequently, this chapter serves both, as a proof-of-concept to demonstrate the feasibility of the system design presented in Chapter 5 and Chapter 6, and aims to make an additional contribution through the documentation of experiences and reasoning derived from empirical evaluation of the IT artefact.

This chapter presents the complete prototype development, including the necessary data structures and algorithms. Another core goal of this chapter is to make a contribution to the scientific knowledge base derived from detail aspects of the developed system. As has been noted in the method chapter, this research follows a theory-driven design approach organised in four design phases. To structure the system development in smaller, more manageable parts, the prototype development is also arranged along these four design phases:

- Component One - Base-Line Innovation Portal (front-end)
- Component Two - Process-Based, Open-Ended Platform (back-end + management)
- Component Three - Idea Rating Mechanisms (an operational efficiency feature)
- Component Four - Guided User Interaction (a generative capacity feature)

To present the overall functionality of the prototype, we rely on the use case technique. Use cases are a method to capture the functional requirements of a system (Fowler, 2003). They describe the typical interactions between the users of a system and the system itself. Thus, use cases provide a narrative of how a system is used. For the graphical

C. Riedl, *Tool-Supported Innovation Management in Service Ecosystems*,
DOI 10.1007/978-3-8349-6802-9_7, © Gabler Verlag | Springer Fachmedien Wiesbaden GmbH 2011

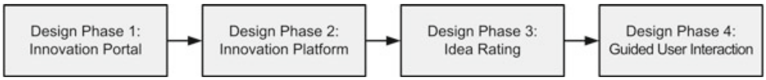


Figure 7.1: *Course of this research.*

representation of the use cases we rely on UML notation. The document structure of the implementation sections follows the use case structure.

The following four sections describe the analysis, design, implementation, and evaluation of each of the four components in turn. Figure 7.1 repeats the overview of the course of this research and the four prototype components from Section 5.4.2. To ensure consistency and comprehensibility, the description of each component follows the same structure:

- Aim and Scope
- Related Work
- System Design
- System Implementation
- (Experiment Set-Up)
- Artefact Evaluation
- Discussion

The "Experiment Set-Up" section is only present for component three and four which include empirical evaluation. While component three and four substantially extend the theoretical foundations laid out earlier, not much additional theoretical background is necessary for component one and two as the concept of open innovation and the theory of generative capacity have already been introduced in length. However, to provide coherence and intelligibility of the individual component sections, they are briefly reiterated.

7.1 Component One: Innovation Portal

The integration of customers and suppliers into the innovation process is one of the biggest resources for external innovations (cf. Section 3.5). The integration of additional third parties like domain experts or customers of competitors could also be used to further broaden the scope of external input. In the remainder of this work, all actors that are external to a company are subsumed under the community member role. In the particular context of service ecosystems, services are expected to be characterised by a high degree of outsourcing and are consequently jointly provided by a network of actors. Service ecosystems are open and flexible systems with a great number of actors that participate on the platform. For example, service providers might be interested in working together to develop new services. Consequently, there is a need for collaboration and an open system to foster innovation in the ecosystem (cf. Chapter 5). To facilitate the integration of the various external actors and provide a collaboration environment for the actors of service ecosystems to jointly develop new services a tool is required that supports this integration. One successful approach is to build a virtual community supported by an online platform (Leimeister et al., 2009). The first component of the TEXO Innovation Repository implements a base-line innovation portal to support an online innovation community of service

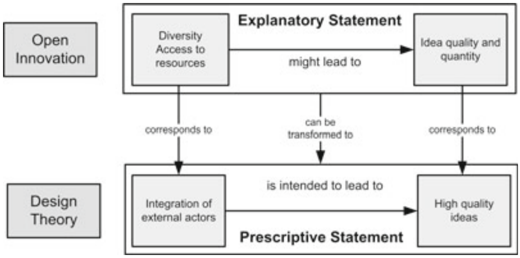


Figure 7.2: *Design theory for the first prototype component.*

ecosystem actors. Furthermore, the first component serves as a base-line on which the other components can build. It is based on the features provided by existing innovation portals on the Internet. The innovation portal implements features such as submitting ideas, exploring ideas, writing comments, and rating ideas.

7.1.1 Aim and Scope

The aim of component one is to implement a communication platform to realise the vision of a central innovation space through which the actors of a service ecosystem can interact and exchange innovation relevant information (cf. central architectural design in Section 5.1.2). The aim is, furthermore, to provide a platform that is generative on the content level, i.e., a platform that allows its users to contribute any idea, requirement, or improvements they might have (cf. generativity on the content layer in Section 4.5 and the different actors and types of contributions identified in Section 5.1). The focus of component one is on generativity on the content level and not on the technology level. The central input for this first component is requirement C3 “Provide a shared innovation space” and C4 “Support integration of different actors.” The following sections detail the design theory developed for this component based on the design rationale presented in Section 5.4.2.1. Figure 7.2 gives an overview of the mapping of the cause-effect relationship on the means-end relationship.

Cause-Effect The paradigm of open innovation has not been formalised as a kernel theory using a cause-effect relationship in the narrow sense. However, building on the underlying concepts and aims of open innovation the system design chapter developed a cause-effect relationship. The cause-effect relationship thus developed consists of two parts: first, the positive impact of the integration of external sources of innovation into a company’s innovation process on reach (open innovation ⇒ more ideas); second, the positive effect of the integration of external sources on the depth and diversity (open innovation ⇒ idea quality). Overall, open innovation has been found to increase a company’s innovativeness and a cause and effect relationship can be expressed as: integration of external sources of innovation ⇒ increased idea quantity and quality.

Means-End As with the cause-effect relationship, the aim of the design theory is to increase the quality and quantity of ideas in the repository. To start the causal process, the integration of external actors into the innovation process through the use of a central innovation space has been chosen as a suitable means. Service ecosystems consist of a tight network of actors developing and offering services together. This resulted in requirements C3 and C4. The integration of these actors into the innovation process through a central innovation space which allows information exchange and supports communication has been identified as the resulting design theory for component one. The system can thus create value through the aggregation of individual user contributions (Gruber, 2008).

In summary, the aim and scope of this component is the implementation of an online innovation portal. This portal serves as a central innovation space that allows information exchange and collaboration between the different actors identified within service ecosystems. The innovation portal is then expected to influence the cause of the “open innovation theory” (integration of external sources of innovation) that is expected to increase idea quality and quantity. The aim is to implement a base-line innovation portal that offers functionality similar to that of other innovation portals on the Internet that have shown to be useful means to integrate external actors into the innovation process (Ebner/Leimeister/Krcmar, 2009; Leimeister et al., 2009; Di Gangi/Wasko, 2009). Furthermore, the innovation portal offers the necessary ground work and user interface on which the other components of the TEXO Innovation Repository can then build. Such a user interface is necessary, in particular, for the experiments analysing the effectiveness of the rating mechanisms (component three, Section 7.3) and guided user interaction (component four, Section 7.4).

Section 6.3.2 presented an empirical analysis of innovation portals. This empirical analysis, together with a set of competency questions, defined the scope of the Idea Ontology. This empirical analysis is also used to define the necessary features of the innovation portal developed in this component. From the empirical analysis we identified the features that the innovation portal should have. The detail analysis of the required features is presented in the following list.

Post ideas Depending on the aim of the innovation platform the ideas to be posted on the platform range from incremental additions or improvements to an existing product to the posting of completely new products or service ideas. The form in which ideas are posted ranges from short, unstructured textual descriptions (commonly one to three short paragraphs) to full business plans including target customers, business models, competitors, and other supporting material such as images and additional documents. To support these more advanced usages the ability to attach additional material such as images or office documents is necessary.

Comment ideas Other actors of the innovation community can comment on ideas and thus engage in discussions about the idea. The aim is to refine and improve ideas. In order to comment ideas, some form of idea exploration is necessary. To browse ideas in the innovation portal ideas can usually be sorted by different attributes (e.g., title or number of comments).

Rating of ideas To support idea evaluation some sort of idea rating is commonly supported. The most popular rating method is a very basic “promote/demote” rating. Here, the rater can leave a simple “thumbs-up” or “thumbs-down” rating depending on how he/she liked the idea. An alternative rating method is a “5 star” rating where the user can assign one to five stars according to the user's judgement of the idea.

Tagging of ideas To support an organisation of the ideas in an idea repository, tags are commonly used to structure the idea pool. Here, either the original author of an idea or other actors on the platform can assign tags to an idea.

Community building To support community building innovation portals usually provide some form of personalised user area. This personalised area contains information about the user profile (e.g., name, userID, and e-mail address) and a list of ideas that the user has created or has contributed to. Sometimes some form of bookmarking, or "watch list," is available to save ideas for future reference.

Communication support To allow additional communication between community members, online innovation portals offer additional communication channels. Most common is an internal messaging service or an integration with e-mail or instant messaging.

Based on this abstract feature list, we identified a detailed set of use cases to be implemented by the innovation portal. Figure 7.3 shows a summary of all use cases. Through these functions the collaborative innovation portal also functions as a knowledge management tool. It addresses the core needs of creative teams to develop a shared understanding, offers opportunities for interaction, and the rapid creation and sharing of context specific transient information (Malhotra et al., 2001).

7.1.2 Related Work

This section reviews and collects related work on the design and implementation of an innovation portal. The functional requirements of the innovation portal have been determined through an empirical analysis of existing innovation portals. This empirical analysis has been presented in Section 6.3.2. Additional research regarding the use of innovation portals in an open innovation context has already been referenced in Chapter 3 which presented related work on this issue.

7.1.2.1 User-Generated New Service Ideas

Generally, new service ideas are creative products which combine existing elements in a novel manner. The ideas are the result of a non-deterministic creative process and yield semantic information that overlaps the information in the initial knowledge (Johnson-Laird, 1993). In the context of the innovation portal described in this component, the users generating these new service ideas are the different actors of a service ecosystem. In the specific case of customer-generated new service ideas, these may be of great value for a company as they provide novel information about customers needs. This is referred to as *need information*. Furthermore, customers can provide information about new ways of fulfilling these needs that have hitherto not been considered by the company. This is referred to as *solution information* (von Hippel, 1994). Both need information and

Figure 7.3: *Front end use cases of the community member role.*

solution information are known to be “sticky” which means that this information is costly to move from the site where the information was generated (the customer) to other sites (the adopting company) (von Hippel, 2005). Integration of customers into the innovation process, e.g., through the use of an innovation portal, offers a means to collect this sticky information. However, these ideas are often not very specific and show a rather low degree of elaboration and maturity. Usually, they have not been revised (Blohm et al., 2011a; Blohm et al., 2011b) or consolidated (Di Gangi/Wasko, 2009). Thus, customer-generated new service ideas are often vague and blurry. Furthermore, as these ideas are generated independently there is a high degree of redundancy (Di Gangi/Wasko, 2009). Moreover, the pre-existing structures such as the strategic fit of an idea with the adopting company have usually not been taken into account in the idea generation process of customers. This may be different in the case of ideas generated by suppliers or business partners who wish to communicate information based on new developments or additional requirements. To reflect the different levels of abstraction that user-generated new service ideas might have we designed the Idea Ontology to support three levels of idea description: a title, a short abstract, and a longer description. The ability to attach additional documents can be seen as a fourth level offering additional details. This hierarchical design has been implemented in the innovation portal which allows assigning a separate idea title, description, and attachments. The abstract layer is not implemented in the innovation portal.

7.1.2.2 Collaboration

Collaboration comes from the Latin word *collobare* which means “to work with.” Thus, collaborative efforts are joint, rather than individual. The collaboration process is commonly considered to consist of communication, coordination, and interpretation (Amabile, 1983). Joint efforts can be distinguished from individual efforts if they are directed towards a group goal (Kolfschoten et al., 2010). Collaborating individuals combine their efforts to achieve mutually desired states of outcomes. Collaboration can thus be defined as “joint effort towards a group goal” (Kolfschoten et al., 2010, 303; see also Nunamaker/Briggs/de Vreede, 2001). A key condition for successful collaboration is interaction and communication between individuals. Without interaction, participants cannot define their group goal and cannot commit to it. Furthermore, interaction is necessary to attune participants’ behaviours towards goal attainment. Consequently, appropriate communication channels are a necessary resource for collaboration (Kolfschoten et al., 2010).

7.1.2.3 Communication Support

Communication is a central aspect of collaborative problem solving (see above), particularly in the context of distributed teams (Riemer, 2009). To add communication support to the innovation portal two general approaches are possible. Either, the innovation portal provides its own communication support or existing communication media, such as e-mail, are integrated. Following the concept of *Unified Communications* (Riemer/Taing, 2009) we chose to integrate existing communication components. This allows us to leverage the wide distribution and popularity of existing concepts and applications. To support both synchronous and asynchronous communication we chose to integrate e-mail and Instant Messaging. Instant Messaging (IM) is a text-based, near-synchronous communication between two or more users who usually know each other (Li/Chau/Lou, 2005). IM systems typically include a pop-up mechanism that notifies users about new messages, a contact list, notifications about user's connection status, customisable appearance and status messages, and other features (Li/Chau/Lou, 2005; Quan-Haase, 2008). Instant Messaging is regarded as a form of informal communication similar to face to face interaction and therefore generally is impromptu, brief, context-rich, and dyadic (Nardi/Whittaker/Bradner, 2000). These characteristics allow for joint problem solving, coordination, social bonding, and social learning; activities which are the foundations for complex problem solving (Nardi/Whittaker/Bradner, 2000). Instant Messaging offers immediate gratification by providing real-time, instantaneous communication (Fichter, 2005). Thus, minor matters can be cleared up instantly between users who are collaborating on an idea. Popular free IM services are, for instance, AOL Instant Messenger, Windows Live Messenger, ICQ, or Skype. We chose to integrate Skype[1] because it is freely available, in widespread use, available for many different computer systems, and offers the necessary functionality that allows integration into the innovation portal (Riemer/Frößler/Klein, 2007). Skype has been integrated with support for real-time availability status. This means that a user's connection status is directly visible in the innovation portal. This can be used to create awareness and social presence (Nardi/Whittaker/Bradner, 2000; Köbler et al., 2010a; Köbler et al., 2010b) as the communication media includes presence signalling (Riemer/Taing, 2009).

7.1.2.4 Rich Internet Applications

Rich Internet applications (RIAs) are Web applications that offer responsiveness, "rich" features, and functionality similar to that of desktop applications (Deitel/Deitel, 2008). Contrary to early Internet applications that supported only very basic HTML-based user interfaces, rich Internet applications aim at providing a look-and-feel similar to desktop applications. Rich clients provide advanced GUI features such as drag-and-drop, menus, or toolboxes (Vossen/Hagemann, 2007). A core technology to implement RIAs is *AJAX*, a shorthand for Asynchronous JavaScript and XML. AJAX allows partial page updates and server requests that run in the background without the need to reload the entire Web page. This creates a more responsive GUI, allowing users to continue interacting with the page while the server processes requests and content is updated at the client-side. Data are usually retrieved using the XMLHttpRequest object (Deitel/Deitel, 2008). The term *Web 2.0* is sometimes used to refer to the a collection of technologies such as AJAX, RSS, and REST (cf. Section 7.2.1) that form the basis of rich Internet applications (Sheth/Verma/Gomadam, 2006; O'Reilly, 2007).

A fundamental step in the development of design principles is the explication of design decisions. In the development of the innovation portal as a rich Internet application we relied on established design patterns that serve as our design rationale. A pattern is a recurring, but also reusable problem solving schema (Alexander/Ishikawa/Silverstein, 1977). Design patterns are prevalent and well established in computer science and software engineering (Schermann, 2009; Kolfschoten et al., 2010). In software engineering

[1] `http://www.skype.com/intl/en/` (last accessed 2010-10-26)

design patterns offer elements for reusable software development (Gamma et al., 1995). Design patterns are particularly useful in the area of interface and interaction design. Not only do patterns encapsulate best practices and capture common solutions thus making the design process simpler for those who write the software but they also help to meet user expectations through adherence to well known structures and names. In general, established design patterns for good website design have been used. Several websites such as UI-patterns.com[2] and Yahoo,[3] and books (van Duyne/Landay/Hong, 2003; Tidwell, 2006) offers good collections of established design patterns for interface and interaction design. Where appropriate, we provide references to established design patterns used in the TEXO Innovation Repository.

7.1.3 System Design

The innovation portal implemented in this component, as the name already suggests, follows an architectural style called *portal* (Raol et al., 2002). A portal is a Web-based application that provides single sign on and content aggregation from different information sources. A portal provides the presentation layer of an information system. Aggregation is the action of integrating content from different sources within a Web page. A portal may also have sophisticated personalisation features that provide customised content to users. Portal pages usually consist of different sets of so called *portlets* creating content for different users. A portlet is a Java technology-based Web component (Abdelnur/ Hepper, 2003). Portlets are managed by a portlet container that processes requests and generates dynamic content. In the case of the TEXO project, the Liferay Portal has been chosen as the portal container (cf. system details in Section 5.4.3). Portlets are used by portals as pluggable user interface components that provide a presentation layer to an information system. Through the use of the flexible portlet technology system functionality can be packaged in individual portlets which can then be re-combined to create customised content pages for different users. The use cases identified above have been decomposed into a set of portlets which then provide the necessary functionality to satisfy the use cases. Table 7.1 summarises the portlets and the use cases each of them implements.

7.1.4 System Implementation

This section provides an overview of the resulting system implementation of component one. It provides in particular screenshots of the different portlets and describes their functionality. Figure 7.4 provides a full view of the TEXO Innovation Repository front-end as it shows up in a Web browser. The individual parts of the screen are explained in more detail with additional screenshots in the following sections.

[2] `http://ui-patterns.com/` (last accessed 2010-10-26)

[3] `http://developer.yahoo.com/ypatterns/` (last accessed 2010-10-26)

Portlet	*Use Cases*
Innovation Repository	Explore contributions (list and search)
	Explore individual contribution (idea detail page)
	Start search on related terms
	Submit idea (edit idea, submit tags, upload attachment)
	Submit comment
	Submit rating
	Communicate with other users
	Subscribe to RSS
User Home	List of own ideas
	List of commented ideas
	List of rated ideas
	Watch list
Quick Entry	Submit idea
Tag Cloud	Explore contributions by tag
Status	Explore statistics

Table 7.1: *Summary of front-end portlets and implemented use cases.*

7.1.4.1 Idea Toolbox

A central component common to different use cases is the toolbox displayed to the right of each idea on the homepage (Figure 7.4, pattern "button group," Tidwell, 2006). Most use cases can be triggered through this toolbox. Rather than scattering functionality over different places, the toolbox uses a button group of the same size and alignment which allows convenient access to different functionality in a single place. Table 7.2 explains the symbols of the idea toolbox.

7.1.4.2 Use Case: Community Member - "Explore Contributions"

To explore ideas in the repository, community members can access a variety of functions (see central area in Figure 7.4). As default, a list of the most recent contributions is shown. This list can be sorted according to various parameters, such as the number of comments, rating, or alphabetically. The different lists are organised as tabs at the top of the page ("navigation tabs" pattern, Tidwell, 2006). These navigation tabs relate to the physical metaphor of folders in a file-cabinet and are thus familiar to the user. In addition, it is possible to access contributions using a tag cloud or look for specific ideas via a search function (middle right part in Figure 7.4). The list of ideas is dived into sub pages ("pagination" or "one window paging" pattern, Tidwell, 2006). The number of ideas displayed per page can be changed via a central configuration file.

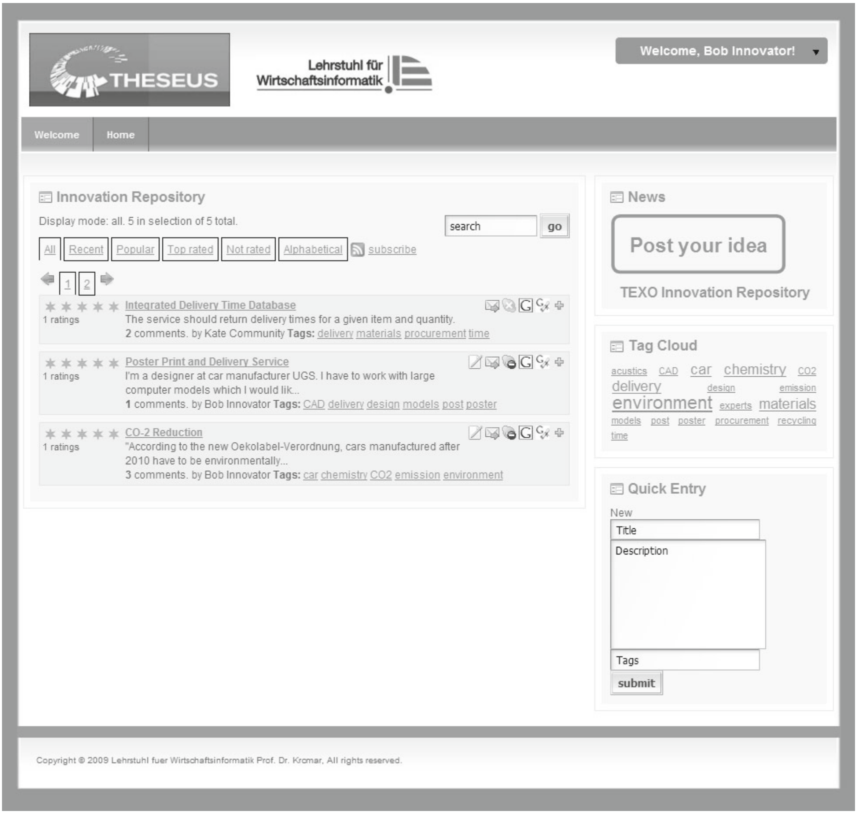


Figure 7.4: *TEXO Innovation Repository: homepage.*

7.1.4.3 Use Case: Community Member - "Explore Details"

Community members can explore a contribution by clicking on it which opens up a detailed view of the idea submission (Figure 7.5). The submission and all related information including attachments, comments, and metadata are shown. In case of image attachments (such as JPEG or PNG images) the images are directly displayed in addition to a download link. All file attachments can be downloaded by clicking on the "download" link next to the file name.

7.1.4.4 Use Case: Community Member - "Explore Statistics"

A simple statistic overview can be added to the main page that shows the total amount of submitted ideas and comments (Figure 7.6). This gives community members and innovators an overview of the current state of innovation activities.

Symbol	*Description*
	The edit icon is only visible when the current user is the author of an idea. Clicking on the edit icon opens the idea in the edit form. This allows the author to edit the idea title, description, tags, as well as to add or remove document attachments.
	The e-mail icon is visible to all users on all ideas. Clicking on the e-mail icon opens the e-mail address of the author of an idea as a *mailto* link in the user's e-mail program.
	The Skype icon allows a community member to start an Instant Messaging conversation with the author of an idea. The Skype icon displays the user's real-time status which is intended to create a feeling of awareness and allows immediate interaction (Köbler et al., 2010b).
	The Google icon starts a search on the tags of an idea in a new browser window.
	The Google Scholar icon starts a Google Scholar search on the tags of an idea in a new browser window.
	The green plus icon adds an idea to the user's personal watch list. The red minus sign indicates that an idea is already on a user's watch list. Clicking on the minus sign removes the idea from the watch list.

Table 7.2: *Symbols used in the toolbox of an idea.*

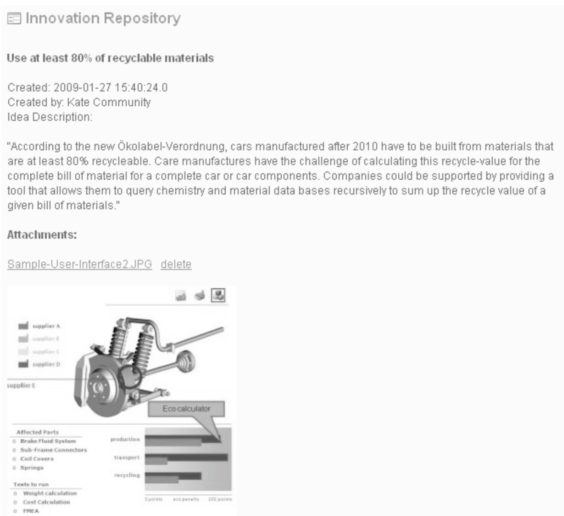


Figure 7.5: *TEXO Innovation Repository: explore individual contribution.*

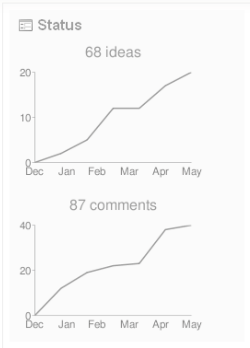


Figure 7.6: *TEXO Innovation Repository: explore simple statistics.*

7.1.4.5 Use Case: Community Member - "Search Related Terms"

Community members can quickly start a search on the tags provided for an idea with the integrated Google and Google Scholar search. By clicking the button in the toolbox (Section 7.1.4.1) the search is executed in a new browser window. This function allows community members and innovators to perform quick research on the key terms (the tags) used to describe an idea.

7.1.4.6 Use Case: Community Member - "Submit Idea"

New ideas can be submitted using either the "Post your idea" form or the "Quick entry" form (Figure 7.7). In either case the community member has the opportunity to add an attachment to the idea which can be of any file type and up to 16MB in size. Pictures in the JPEG or PNG format are shown as a preview in the contribution overview. On the same screen as submitting an idea, community members can also add attachments and tagging information (see use cases described below).

7.1.4.7 Use Case: Community Member - "Edit Idea"

Community members can edit their own ideas in order to correct errors or add information. The procedure is the same as submitting a new idea. In particular, the author of an idea can come back to upload attachments and add tags to achieve a more detailed classification of the idea.

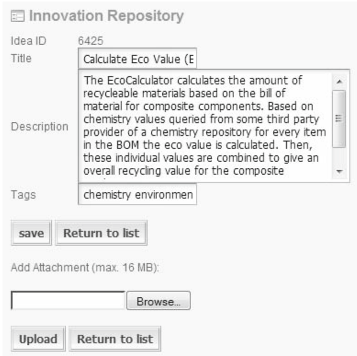


Figure 7.7: *TEXO Innovation Repository: submit idea.*

7.1.4.8 Use Case: Community Member - "Submit Tagging"

The author of an idea can add metadata in form of tags to an ideas in order to characterise them. These tags will be recognised by the search engine as well as by the tag cloud which is based on them. Tags can be submitted via the "Add Idea" or "Edit Idea" use case.

7.1.4.9 Use Case: Community Member - "Upload Attachment"

The author of an idea can upload attachments when they submit or edit an idea. The file chooser button is visible at the bottom of Figure 7.7. An attachment may consist of files of any type or size up to 16 MB. Existing file attachments can also be removed by the author by clicking on the "delete" button.

7.1.4.10 Use Case: Community Member - "Submit Comment"

Community members can comment on ideas to start discussions, add or correct information, and express their opinions. Comments can be submitted through a form displayed on the detail page of an idea, directly below the list of existing comments. Users can thus directly start typing a comment after reading the idea description and discussion without the need to load an extra page containing the comment form. This is shown in Figure 7.8. The number of comments submitted for an idea is displayed on the homepage to indicate the popularity of an idea.

7.1.4.11 Use Case: Community Member - "Submit Rating"

For the initial version of the TEXO Innovation Repository, a 5-star rating mechanism has been implemented. Community members can submit a rating for an idea to express their

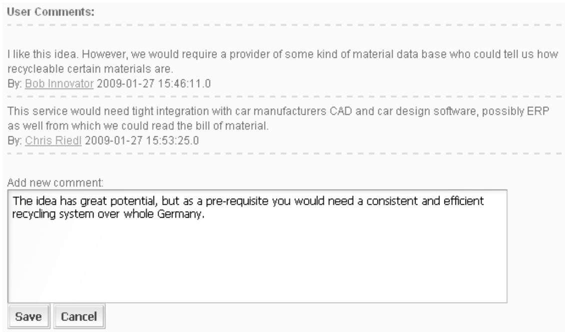


Figure 7.8: *TEXO Innovation Repository: submit a comment.*

opinion about it. The best rating being five stars, the worst rating one star. The rating is performed directly on the main page, displaying all ideas (see Figure 7.4): initially, the average community rating for an idea is displayed in a highlighted orange colour. Through a dynamic mouse-over effect the user can move the mouse over the five stars to choose the rating to submit. On clicking on one of the stars, the user can then submit his or her rating which is then sent to the server via AJAX running in the background. This does not require a new page to be loaded and the rating is automatically incorporated into the average community rating. A counter of the number of ratings for an idea below the star icons is incremented and the orange highlighting is updated to indicate that the rating has successfully been submitted. Thus, a visual feedback about the successful rating is immediately provided. Every user can rate each idea only once. In case a user submits a new, second rating the old one is updated.

7.1.4.12 Use Case: Community Member - “Communicate”

Community members may engage in communication with other members by means of e-mail or Instant Messages via Skype. These functions are easily accessible via the toolbox beside each idea. This allows for quick interaction between community members and innovators. The feature can stimulate creativity and facilitate close collaboration. All occurrences of user names (e.g., as author of an idea or author of a comment) are linked to the user’s e-mail address.

7.1.4.13 Use Case: Community Member - “Subscribe to RSS Feed”

Community members may subscribe to the RSS feed via a link in the browser’s address bar or via a button on the detail page to receive updates about new scenarios and ideas via an RSS reader, their e-mail application, or their browser (Figure 7.9). This allows community members, and especially the innovator to stay up-to-date on new idea submission. Two types of RSS feeds are available. First, a feed of all ideas contained in the repository is available. This feed contains new ideas that are submitted to the TEXO Innovation

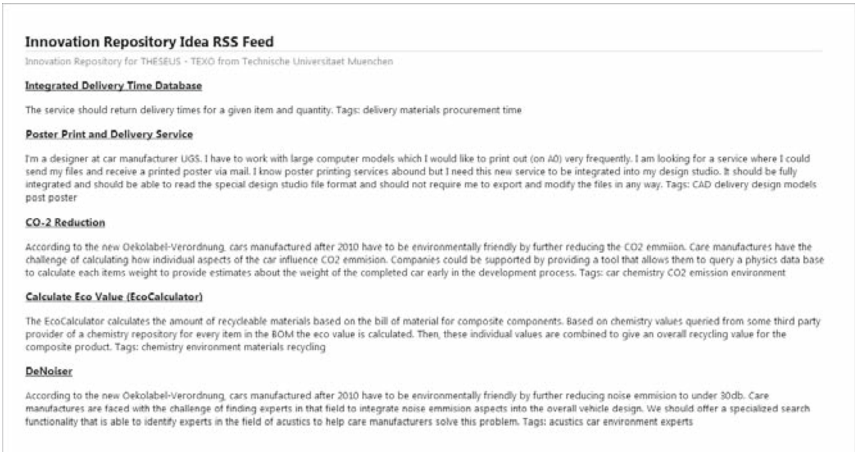


Figure 7.9: *TEXO Innovation Repository: subscribe to RSS feed.*

Repository. The second feed is a detail feed for a selected idea. This feed contains new comments submitted to a selected idea. The second feed is intended for the a user, in particular the author, interested in the development of a particular idea.

7.1.4.14 Use Case: Community Member - "Browse User Homepage"

The personal user homepage provided by the User Home portlet is a central component of the community building aspects of the innovation portal. In addition to general information about the user like name and e-mail address it provides a list of ideas that are relevant to that user. The list includes ideas that have been authored by that user, ideas that the user has commented on, ideas that the user has rated, as well as ideas that the user added to his or her personal watch list. This gives users a convenient way to keep up-to-date on ideas he or she is interested in by making these ideas accessible at a central place in the innovation portal.

7.1.5 Artefact Evaluation

The innovation portal developed in component one serves as a base-line portal and provides central functionality for components two, three, and four. Consequently, the innovation portal has been part of all evaluation activities of these components. The experimental evaluation of the idea rating component (Section 7.3) in particular includes usability aspects that are related to the functionality provided by the innovation portal.

The innovation portal has received substantial formative evaluation. As it provides necessary core functionality for all other components the innovation portal has been used in several demonstrations and was a central part of the experiments conducted for component

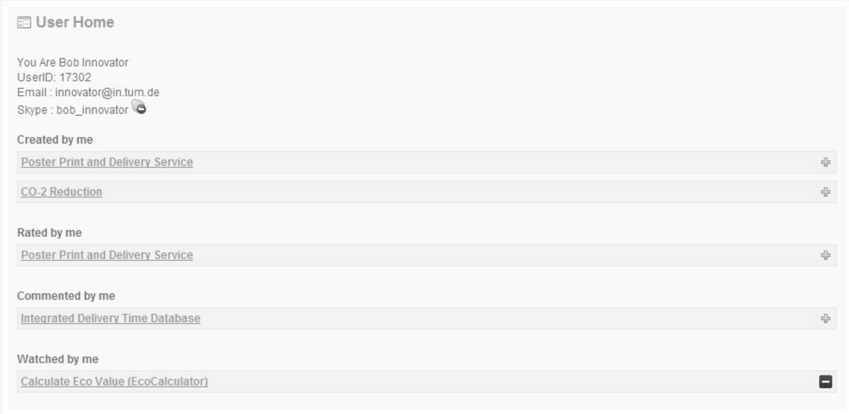


Figure 7.10: *TEXO Innovation Repository: user home screen.*

three and four. Through formative evaluation the innovation portal has been constantly refined and improved to implement experiences from tool usage. We constantly involved potential users in the system design. This feedback collection involved several informal think-aloud session (Hwang/Salvendy, 2010) with colleagues, project and industry partners, and others, e.g., as we demonstrated the system on fairs, project meetings, and the TEXO SME Initiative. Furthermore, the innovation portal has been used to collect feedback and ideas for one of our lectures between April and June, 2010. Different studies suggest different numbers of people to involve in usability evaluations. Hwang/Salvendy (2010), for example, suggest 10±2 people for a successful usability evaluation. The number of people involved in our usability evaluation easily exceeds the number of people commonly suggested for this type of evaluation. The formative evaluation lead to various improvement and extension. In particular bugs have been removed and issues with usability have been addressed. For example, in the initial design users would return to the detail page after submitting an idea. On this page, users were irritated by the "save" button of the comment field. Many users thought that they now had to save their idea and clicked on the "save" button. This caused the system to submit an empty comment to an idea. This issue has been solved by changing the system to return to another empty idea input form after successfully submitting an idea.

On a summative evaluation level, all empirically collected uses cases presented in Section 7.1.1 have been implemented. Consequently, component one provides a functionally complete innovation portal. As the innovation portal offers similar features as other innovation portals it is reasonable to expect that the program is able to start the causal process predicted by the open innovation paradigm. Successful community building has been demonstrated in different cases (e.g., Leimeister, 2005; Leimeister/Krcmar, 2006; Ebner, 2008; Bretschneider, 2010). As the innovation portal offers similar functionality we argue that it would be possible to build a community using the innovation portal. Only little additional insight beyond established knowledge could be expected from an empirical evaluation at this stage. In this particular case, we argue that an additional empirical system evaluation is not urgently necessary (cf. Section 2.2.5).

The central learning of the development and evaluation of the innovation portal is summarised in the following box.

> **Implications for the System Design** A sophisticated system including many front-end functions is necessary to facilitate high-quality evaluation. These system functions need to be of a sufficiently mature state so that they can be used in experiments that focus on other aspects. Otherwise, experiment results could be compromised by a faulty system and a confusing interface design.

7.1.6 Discussion

This section presented the detail design and resulting implementation of component one, the innovation portal. Based on an empirical analysis of existing innovation portals a set of use cases has been identified. These use cases have then been decomposed into a set of portlets which implement the necessary functionality. The innovation portal has three central aims. First, it offers a means to integrate external actors into the innovation process and thus to start the causal process predicted by the open innovation paradigm of increased innovativeness. Second, it provides a central innovation space that can be used by the actors of a service ecosystem to exchange information and collaborate on the development of new services. Third, it serves as a base-line tool offering the necessary basic functionality for the more advanced components that follow. The innovation portal is a generative tool on the content level as it allows its users to choose what and how they want to contribute to the shared innovation pool. However, the innovation portal is only a stand-alone tool without process support and no support for generativity on the technology level. This aspect is addressed by component two in the next section.

7.2 Component Two: Process-Based, Open-Ended Platform

The innovation portal developed in the first component offers a central innovation space through which actors of a service ecosystem can interact and exchange information. However, the community functions need to be supplemented with additional management functions to ensure that ideas can systematically be developed, implemented, and tracked along their life-cycle. The additional functionality of the TEXO Innovation Repository developed in component two implements the vision of an open-ended and process-oriented system. The resulting prototype allows the integration of external special-purpose applications that can be freely configured and ordered to support any number of innovation scenarios and innovation processes. Component two implements the necessary innovation repository back-end functionality, in particular through the instantiation of the Idea Ontology. Furthermore, component two adds process modelling and workflow execution to the TEXO Innovation Repository.

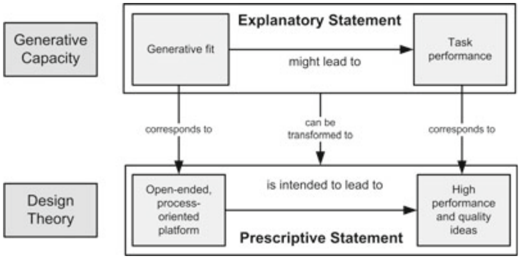


Figure 7.11: *Design theory for the second prototype component.*

7.2.1 Aim and Scope

While component one provides necessary front-end functionality to collaborate on idea development, it does not yet implement the main concepts of the unified framework and core system design developed in Chapter 5. The central aim of component two is to develop the necessary functionality to realise the unifying framework of a process-based, open-ended, central repository that can support both generative capacity and operational efficiency features through the integration of special-purpose applications. The resulting application allows the integration of external special-purpose tools that can be freely configured and ordered to support any number of innovation scenarios and innovation processes. For that purpose, component two builds the necessary back-end functionality to implement a repository based on the Idea Ontology developed in Chapter 6. This ontology-based back-end solves the central integration problem and allows the integration of external applications through a central data structure. Furthermore, component two adds the necessary management functionality to allow the design and execution of innovation processes through a workflow system based on collaboration engineering. Key inputs are requirements C1 “service life-cycle,” C2 “cyclic innovation phases,” C5 “integrate special-purpose tools,” and C6 “ideas in different phases” (see Chapter 3). In summary, the overall scope of component two is the instantiation of the Idea Ontology and the realisation of the Integrated System Design presented in Chapter 5. To improve coherence and intelligibility the next two paragraphs reiterate the cause-effect and means-end relationship before the remainder of this section presents the detail design and implementation. Figure 7.11 gives an overview of the mapping of the cause-effect relationship on the means-end relationship.

Cause-Effect Section 5.4.2 introduced the theory of generative capacity as kernel theory for component two. The theory can be expressed in a cause-effect relationship as follows: generative fit $\Rightarrow$ better use of generative capacity. Chapter 4 reviews the theory and related concepts in detail; no additional review is necessary at this stage. The theory also constitutes requirement C7 and is the basis for the unifying framework to achieve a blend between generative and operational efficiency features.

Means-End Chapter 5 and in particular Section 5.2 elaborated on the overall architectural design of the TEXO Innovation Repository which is implemented in component two. Consequently, the effect of the theory of generative capacity can directly be transformed into the aim (“is end”) of the design theory: more and better ideas. Chapter 5 argued in detail how the architectural design of a central, process-oriented, open-ended platform serves as a means to achieve this goal. Furthermore, the Idea Ontology presented in Chapter 6 provides the necessary integration on the data layer in order to implement such a central repository.

Process-orientation is achieved through the implementation of a workflow management system (van der Aalst/van Hee, 2004) that allows the design and execution of customised innovation processes. As innovation processes are predominantly collaboration processes (van de Ven, 1986), the workflow management system is based on the concept of collaboration engineering (Kolfschoten/de Vreede, 2009). To implement an open-ended repository some form of interface for the resulting networked system is necessary. We chose the Representational State Transfer (REST) architectural styles over other network-based styles for its simplicity (O'Reilly, 2007), the uniform interface between components (Fielding, 2000), and its ability to leverage the benefits of Semantic Web technologies (Battle/ Benson, 2008). The REST style in particular allows for loosely coupled systems and thus fosters independent evolvability which has been identified as a key characteristic of generative systems (cf. Section 4.4; in particular D4 *Integration* and D9 *Rejuvenation*). The focus of the TEXO Innovation Repository is to provide a central platform that allows the integration of special-purpose applications rather than to provide every necessary function by itself. Through the flexible data scheme provided by the Idea Ontology, special-purpose applications can be connected to the TEXO Innovation Repository to provide the necessary innovation support. The innovation portal developed in component one is one of these special-purpose applications: a specialised component to involve a community of actors over the Internet to support collaborative innovation development. Other special-purpose applications such as specialised rating mechanisms or research tools can also be integrated. The evaluation section of component two provides additional examples of special-purpose applications that have been integrated successfully into the TEXO Innovation Repository.

Based on this abstract feature list, we identified a detailed set of use cases to be implemented by the TEXO Innovation Repository. In particular, we identified a set of necessary management functionalities that allow the operation of such a process-oriented, open-ended system. These management functions are intended for the innovator role as presented in Section 5.4.1. Figure 7.12 shows the use cases of the innovator role. Furthermore, we identified a set of back-end functionalities that other systems need to interact with the central innovation repository to access its data. These functions will be performed by the system role. Figure 7.13 contains a summary of the use cases of the system role.

7.2.2 Related Work

When implementing a process-oriented platform to support innovation processes a key question arises: how can innovation processes be structured? The following sections review related work on how innovation processes can be decomposed and supported by IT systems.

Figure 7.12: *Use cases of the innovator role.*

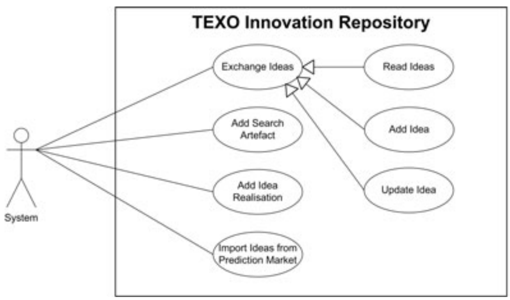


Figure 7.13: *Use cases of the system role.*

7.2.2.1 Structuring Innovation Processes

Innovation processes are commonly structured along four steps: idea collection, idea elaboration or concept development, idea evaluation and selection, and idea implementation (Osborn, 1963; Nunamaker et al., 1991; Cooper, 2008). The aim of idea collection is to collect as many ideas as possible following the assumption that quantity breeds quality. Thus, the chance of an idea collection to contain good ideas increases with the number of ideas (Osborn, 1963). Idea elaboration becomes necessary as idea collection focuses on the generation and collection of ideas, not on their elaboration. Consequently, collected ideas may lack descriptive details to allow adequate idea evaluation and selection. As the number of ideas generated usually exceeds the number of ideas that can be implemented, ideas need to be evaluated so that the most promising candidates can be selected for implementation. Idea evaluation and selection becomes necessary as an organisation's scarce resources need to be allocated to individual innovation projects. Another reason for idea evaluation and selection is companies having a threshold denoting what they deem a valuable idea and ideas evaluated below this threshold will not be implemented (Cooper/Kleinschmidt, 1991). In the last process step an idea is implemented and launched.

A more general distinction in innovation processes is that between a *converging phase* and a *diverging phase* (Osborn, 1963). In the diverging phase one moves from a state of having fewer concepts to a state of having more concepts; in the converging phase one moves from a state of having many concepts to a state of having viewer concepts (Briggs/de Vreede/Nunamaker, 2003). Converging phases comprise steps like screening, selecting, and evaluating alternatives. The converging phase may also include idea elaboration to gain additional focus and understanding of ideas. Osborn (1963) suggests building on existing ideas to improve and combine them in new ways.

7.2.2.2 Collaboration Engineering

Information systems researchers have early joined the efforts of supporting these innovation and decision processes by developing concepts and tool support (Nunamaker et al., 1991; Wagner/Wynne/Mennecke, 1993; Wheeler/Valacich, 1996; Fjermestad/Hiltz, 1999). Group support systems have been developed to enhance group communication and structuring of decision processes (DeSanctis/Gallupe, 1987; Dennis et al., 1988; Schwabe, 1995; Schwabe, 2000; Klein, 2002). To facilitate systematic design and execution of successful, repeatable innovation and collaboration processes, the method of *collaboration engineering* has been developed. Originally introduced by Briggs/de Vreede/Nunamaker (2003), it has since been applied in a variety of studies, e.g., by Bragge/Merisalo-Rantanen/Hallikainen (2005), Kolfschoten et al. (2010), and Nabukenya et al. (2010).

Collaboration engineering involves the design of recurring collaboration processes that are meant to cause predictability and success among organisations' recurring collaborative tasks (de Vreede/Briggs, 2005). Collaboration Engineering is therefore defined by de Vreede/Briggs (2005, 1) as "an approach to the design of re-usable collaboration processes and technologies." The approach aims not only at designing collaboration processes but also at controlling their execution. To consider how a group will accomplish a collaboration task, patterns of collaboration can be used as a means to determine how a group can move through the process to attain a goal (Nabukenya et al., 2010). A key design concept within the collaboration engineering approach is a pattern language to structure collaboration tasks named *thinkLets*.

7.2.2.3 ThinkLets

ThinkLets are design patterns for collaborative interactions (Kolfschoten et al., 2010). Kolfschoten et al. (2006, 613), define a thinkLet as a "named, packaged facilitation technique that creates a predictable, repeatable pattern of collaboration among people working towards a goal." ThinkLets have several benefits to the design of collaboration processes as they permit ease of communication, documentation, and transfer of a collaboration process to others (Briggs/de Vreede/Nunamaker, 2003; de Vreede/Kolfschoten/Briggs, 2006). Thus, they improve the productivity and quality of collaboration processes (Nabukenya et al., 2010). ThinkLets provide a systematic approach to the design of collaboration processes and therefore increase the "engineerability" of collaboration (Kolfschoten et al., 2010). Furthermore, the use of thinkLets has been found to improve the quality of a collaboration process by increasing its efficaciousness, acceptability, reusability, transferability, and predictability (Kolfschoten et al., 2010).

In addition to an assigned name, thinkLets consist of three components: tool, configuration, and script (Briggs/de Vreede/Nunamaker, 2003).

Tool The specific version of the specific hardware and software technology used to create a pattern of collaboration.

Configuration The specifics of how the hardware and software were configured to create a pattern of collaboration.

Script The sequence of events and instructions (oral or written) given to the group to create the pattern of collaboration.

The design of collaboration processes has many similarities with work breakdown structure approaches (without author, 2006), workflow management (Georgakopoulos/Hornick/Sheth, 1995; van der Aalst et al., 2003; van der Aalst/van Hee, 2004), and business process reengineering (Grover/Kettinger, 1995; van der Aalst/ter Hofstede/Weske, 2003). Process design using the thinkLets design pattern, however, is different from these general approaches in that it offers guidelines how processes can be directly supported with collaboration technology (Kolfschoten et al., 2010). A collection of thinkLets becomes a versatile toolbox containing building blocks for collaboration processes which is summarised in Figure 7.14.

Although the thinkLet pattern language is increasingly well elaborated, it does not provide technical details about how a thinkLet-based collaboration system can be implemented. Section 7.2.3.1 presents our approach how to technically implement a process-based collaboration system using the thinkLet pattern language.

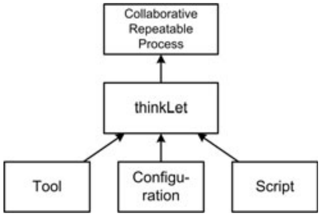


Figure 7.14: *ThinkLets as building blocks of repeatable, collaborative processes (arrows denote an "is element of" relationship; adapted from Briggs/de Vreede/ Nunamaker, 2003).*

7.2.3 System Design

Similar to the implementation of component one, the use cases identified in Section 7.2.1 have been decomposed into a set of portlets. These portlets provide the necessary functionality to support the use cases. Table 7.3 summarises the implemented portlets and the use cases realised by each of the portlets. The following sections explain the system design in more detail: Section 7.2.3.1 shows how we technically implemented the thinkLet pattern language and Section 7.2.3.2 shows how we realised the vision of an open platform that allows the integration of external tools.

Portlet	*Use Cases*
Scenario Admin	Manage innovation scenario Control process execution (start current phase, close current phase, next phase, previous phase, restart scenario)
Idea Admin	Idea administration (view idea distribution, evaluate idea, move idea between phases, delete idea)
Management Dashboard	View "at-a-glance" overview
System Admin	Customise system
GroupSystems Importer	Import ideas from workshop
Ontology modelling tool	Manage evaluation states (which are stored in an OWL file)

Table 7.3: *Summary of front-end portlets and implemented use cases.*

7.2.3.1 Process-Based ThinkLet Implementation

This subsection describes our technical solution implementing a process-oriented innovation system through a workflow system and the thinkLet pattern language. To implement the process-oriented repository, three components are necessary: 1. an innovation scenario which serves as the root element, 2. a workflow component which stores the individual process steps, and 3. one ore more thinkLet(s).

The *scenario* is the root element of our workflow system. Each innovation process is represented by a single scenario. A scenario is in particular identified through a unique `ID` and an Internet domain. Furthermore, a scenario contains a name and a description.

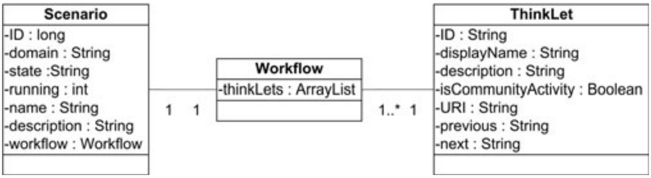


Figure 7.15: *Architecture of thinkLet implementation.*

To control process execution, a scenario keeps track of the current process step (`state` points to an element in the workflow list) and can be set to either "activated" (`running=1`) or "deactivated" (`running=0`). A scenario is linked to a *workflow* which contains a list of all process steps (i.e., thinkLets) that comprise the workflow (1 : 1 relationship) and the ordering of the steps. Finally, a list of *thinkLets* is included. Each thinkLet contains descriptive attributes such as an `ID`, a `name`, a `description`, and an `URL` through which the thinkLet can be accessed. Each thinkLet also contains an indication whether it is a community activity (`isCommunityActivity=true`) or only intended for a specific user group (`isCommunityActivity=false`; e.g., lead users invited to a workshop). Figure 7.15 shows a diagram of the implementation.

Through the `ThinkLet::ID` each thinkLet is linked to its own configuration file which contains the configuration and script. In addition to creating complex, repeatable collaboration processes, this also allows us to integrate a single thinkLet into an innovation scenario multiple times. The innovation portal presented in component one can, for example, be added to an innovation scenario in an "idea generation" configuration and, at a later stage in the innovation process, in an "idea evaluation" configuration. For the persistent storage of the configuration file we chose the standard concept of Java property files. The scenario information as well as the workflow that puts the individual thinkLets into process order is persistently stored in an XML configuration file. While the thinkLet configuration can directly be edited through the System Admin portlet (Section 7.2.4.3), the XML workflow is modified through visual modelling in the Scenario Admin portlet (Section 7.2.4.4) and does not have to be edited manually. This design allows us to implement a template approach on two layers. First, templates for individual thinkLets can be provided (e.g., an innovation portal with an idea generation configuration). Second, templates for a complete innovation scenario consisting of different thinkLets (including detailed configuration) and a workflow can be provided.

As mentioned by Briggs/de Vreede/Nunamaker (2003), a single GSS tool can itself consist of smaller parts and through the use of different configurations provide completely different functionality. As the main objective of component two is to allow the integration of different special-purpose tools, we extended the original thinkLet concept to represent this fact on a technical level. To support the integration of complete tool configurations rather than individual thinkLets into the innovation process, we devised the concept of a *composite thinkLet.* This composite thinkLet acts as a container on a more abstract level for a group of thinkLets (Figure 7.16). This way, the TEXO Innovation Repository is able to integrate complex applications such as the innovation portal presented in component one. This extends the collaboration engineering approach with an additional meta-layer to achieve re-usable building blocks on a higher layer. In the remainder of the work, the term thinkLet commonly refers to our concept of a composite thinkLet.

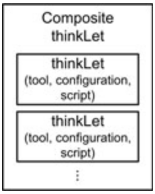


Figure 7.16: *Architecture of a composite thinkLet encapsulating a group of thinkLets.*

7.2.3.2 Open Platform and the Collaboration with External Tools

With the abundance of collaboration and communication tools available in the marketplace there is a general trend towards integrated platforms (Riemer, 2009; Riemer/Steinfield/Vogel, 2009). This is consistent with the design goal followed in this research of an open, extensible repository which integrates other special-purpose applications as an integrated platform (see Chapter 5; cf. also Riemer/Steinfield/Vogel, 2009). To achieve this goal, the design of machine-to-machine communications (i.e., an API) over the Web is necessary. This subsection shows in detail the API design for the TEXO Innovation Repository.

The classical approach to the data aspect of system design distinguishes three models: conceptual, logical, and physical models (Wilde/Glushko, 2008). Generally, there is an implicit assumption that there is a single hierarchy of models and that one data model spans all modelling levels and applies to all the applications in some domain (see, e.g., Rosemann/Green, 2002). For example, in database design, the conceptual models usually conform to the Entity-Relationship (ER) metamodel, the logical model maps ER models to relational tables, and the physical model handles implementation issues such as possible denormalisations. This approach assumes homogeneity which does not work very well for the Web (Wilde/Glushko, 2008). The Web rather presents a constantly growing ecosystem of data and services that evolve in an uncoordinated fashion. This results in a fundamental challenge of matching and mapping local and often partial models that differ in their associated metamodels.

In the context of designing Web service APIs, two competing architectural styles are available. A function-orientated style which is associated with the concept of remote procedure calls (RPC), and a resource-orientated style which is the preferred architectural style for designing loosely coupled information systems (Wilde/Glushko, 2008). Function-orientation relies on a simple data model comprised of simple input/output parameters but requires more functions. Resource-orientation uses a reversed concept. The data model is more complex but less functions are required. The central goal of our design was to develop a communication architecture based on the smallest possible set of assumptions. Therefore, we chose a resource-oriented, rather than a function-oriented design. We expose the data model (in this case “ideas”) rather than relying on some internal model which is unknown to the consumer and a set of complex function-oriented interfaces. This follows the good practice recommendation that an API should be designed by its users, rather than by its providers (Wilde/Glushko, 2008). Such a consumer-oriented definition of the communication form focuses on the simplest possible set of assumptions about potential

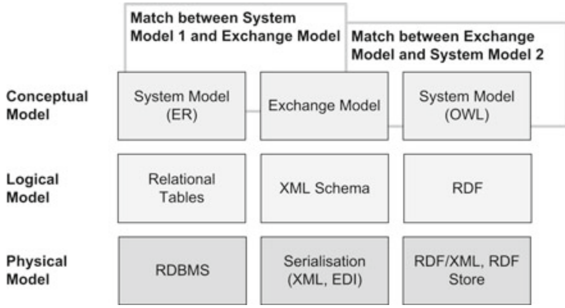


Figure 7.17: *REST modelling layers (adapted from Wilde/Glushko, 2008).*

consumers which makes the API as usable and accessible as possible (Wilde/Glushko, 2008). Contrary to the function-oriented approach where the main aim is integration, the resource-oriented approach focuses on collaboration which is a central design aim of the TEXO Innovation Repository. The resource-oriented approach is also reflected in Schwabe's concept of collaboration through "shared material" (Schwabe, 1995).

When exchanging information on the Web, there usually is no one true data model for a given application scenario. Instead, peers exchange *representations* of resources, hence, the underlying architectural style is called *Representational State Transfer* (REST). Thus, when two peers communicate, three models are involved: the internal model of one peer, the representation model that is used for communications, and the internal model of the other peer (Wilde/Glushko, 2008). This allows participants to use whatever model they see fit for their internal data representation. The peers' internal models are termed *system model* and the representation model used for communication is termed *exchange model* (Figure 7.17).

The system model of the TEXO Innovation Repository is based on the Idea Ontology as the fundamental conceptual model. Different parts of this conceptual model are represented and stored using different logical and physical models (including relational databases and RDF/XML). As the exchange model, we designed a simple XML-based representation of the central concepts of the `im:CoreIdea` class of the Idea Ontology (Listing 7.1). This model is substantially simpler to use than the direct OWL representation of the ontology itself. Furthermore, while understanding of the logical model (i.e., the Idea Ontology) is beneficial, most of what is necessary for the majority of applications interacting with the TEXO Innovation Repository are only ideas in their simplest form.

7.2.4 System Implementation

This section presents the implementation of component two, the process-based, open-ended platform. The section first shows the use of general Liferay functionality (Section 7.2.4.1) followed by the description of innovator use cases (Sections 7.2.4.2 to 7.2.4.8) and system use cases (Sections 7.2.4.9 to 7.2.4.13). Finally, Section 7.2.4.14 presents the implementation of additional front-end integration aspects.

```
<?xml version="1.0" encoding="UTF-8"?>
[...]
    <idea>
      <ideaID>[long]</ideaID>
      <title>[string]</title>
      <description>[text]</description>
      <created>[date]</created>
      <tags>[tags as string separated by blank space]</tags>
      <fiveStarRating>[double value with one decimal place]</fiveStarRating>
    </idea>
[...]
```

Listing 7.1: *Generic XML-based data exchange model used in the TEXO Innovation Repository.*

7.2.4.1 General Liferay Functionality

The complete user management in the TEXO Innovation Repository is performed using the standard functionality of the Liferay portal (cf. Sezov, 2008). This includes in particular user registration, login, and access right management. The two system roles innovator and community member (Section 5.4.1) are organised in two Liferay "communities" which provide access to the functions of the respective system role. The TEXO Innovation Repository thus comprises two communities: a "Guest" community and an "Innovator" community. A user registering a new account is, by default, assigned to become a member of the "Guest" community which comprises all community members. The "Innovator" community is reserved for users of the innovator role. The "Innovator" community requires special permissions which have to be assigned by a system administrator. Through the "Innovator" community users of the innovator role can gain access to the management functions described below. Figure 7.18 shows how a user can change from the guest community to the innovator community through clicking on the "Welcome" button at the top of every page. The Liferay community system offers a simple way to divide functionality for community members and innovators into two separate areas of the TEXO Innovation Repository and provides access control mechanisms.

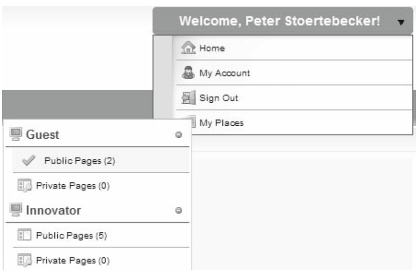


Figure 7.18: *TEXO Innovation Repository: changing from the "Guest" community to the "Innovator" community.*

Figure 7.19: *TEXO Innovation Repository: Management dashboard.*

7.2.4.2 Use Case: Innovator - "View 'at-a-glance' Overview"

The key elements of a dashboard include the aggregation and integration of key performance metrics with underlying drivers to communicate performance throughout the organisation (Pauwels et al., 2009). Thus, the purpose of a dashboard is to counter data overload. The functionality of this use case is implemented through the Management Dashboard portlet. The dashboard (or Management Cockpit) provides a comprehensive overview of the ideas in the TEXO Innovation Repository to evaluate recent activities. Data is aggregated and displayed using common chart elements like pie charts and line diagrams. Figure 7.19 shows a screenshot of the Management Dashboard. Table 7.4 explains the available data in detail. The dashboard can be used to answer key questions about the ideas available in the idea pool (cf. competency questions from Section 6.3.3).

We use Google Charts[4] to dynamically generate graphical pie charts and line diagrams. Additional information is available in the Idea Admin portlet (Section 7.2.4.7), which shows the distribution of ideas between innovation phases.

[4] `http://code.google.com/apis/charttools/` (last accessed 2010-10-26)

Figure	*Type*	*Description*
Share of Commented Ideas	Pie chart	The percentage of commented ideas. This is an indicator for the frequency of community contributions.
Share of Rated Ideas	Pie chart	The percentage of rated ideas. This is an indicator for community interest in posted ideas.
Share of Ideas with Attachments	Pie chart	Percentage of ideas with at least one attachment. This is an indicator for the degree of elaboration.
Top 10 Rated Ideas	Sorted list	The ten best rated ideas. This helps to identify good ideas and attractive topics.
Top 10 Active Users	Sorted list	The ten most active users in terms of contributions (submitting, rating, commenting on ideas). This helps to identify the most valuable users.
Created Ideas by Month	Line chart	This diagram shows the number of ideas created per month for a 12 month period. This helps to evaluate the overall activity on the platform.
Created Ideas total by Month	Line chart	This diagram shows the number of ideas created in total for a 12 month period. This helps to analyse the development of user activity on the platform.

Table 7.4: *Summarised data available in the dashboard.*

7.2.4.3 Use Case: Innovator - "Customise System"

Configuration is defined as "a special type of design activity, with the key feature that the artifact being designed is assembled from a set of predefined components that can only be connected together in certain ways" (Mittal/Frayman, 1989, 1395). The concept is also sometimes called adaptation (Zittrain, 2008). Customisable software allows users to adapt a system or application for their need without writing code (Mackay, 1991).

Using the System Admin portlet, the innovator can configure the behaviour and functionality of the innovation portal implemented by component one. A set of configuration parameters is available that can be adjusted through an input field in the portlet (Figure 7.20). Once the settings have been saved using the "save" button, the changes are immediately active and can be seen in effect once the page is reloaded (runtime configuration). While some parameters mainly influence minor features and the appearance of the system (e.g., enabling the search and sort boxes) other features radically change the behaviour of the system. In particular, it is possible to enable/disable posting of new ideas and writing of comments. Thus, it is possible to configure the innovation portal as a tool to support a diverging or a converging phase of the innovation process.

Using the System Admin portlet the system can, very flexibly, be re-configured to support individual functions within a larger innovation scenario. It can be used to support individual phases of a multi-stage innovation process implementing the concept of *process restrictiveness* (Wheeler/Valacich, 1996). In general, group support systems that provide process restrictiveness can be designed to support a specific function within an innovation process (or agenda) (Phang/Kankanhalli, 2008a). It is also possible to add two or more innovation portals with different configurations to the same innovation process. The complete set of configuration parameters is shown in Table 7.5.

Figure 7.20: *TEXO Innovation Repository: System Admin portlet.*

In addition to the configuration of individual parameters, the system also provides predefined configuration templates. These templates contain combinations of variable settings for several common configurations like idea generation or idea selection. Using the templates, the system stores configurations for completely different tasks. Each configuration template effectively provides a different thinkLet to support specific phases of an innovation process. The configuration templates are automatically loaded when a new innovation portal is added to an innovation scenario (Section 7.2.4.4). Table 7.6 contains the predefined configuration templates and their respective settings.

7.2.4.4 Use Case: Innovator - "Manage Innovation Scenario"

This section describes the scenario administration function implemented by the Scenario Admin portlet. As described earlier, the innovator is responsible for managing the whole innovation scenario (Section 5.4.1). The innovator has to decide which other tools and innovation methods (i.e., thinkLets) should be integrated into the innovation process. The TEXO Innovation Repository allows the innovator to define and control the innovation process via the Scenario Admin portlet (Figure 7.21). Using a AJAX-based drag-and-drop user interface the innovator can visually model an innovation process for the current innovation scenario. The innovator can rearrange the thinkLets in the process. Furthermore, process steps can be removed and new process steps can be added. New process steps are automatically added at the end of the process and can then be dragged to the appropriate position within the innovation process. Using the concept of composite thinkLets (Section 7.2.3.1) each process step is represented by a tool and an accompanying configuration. In particular, all special-purpose tools integrated into the TEXO Innovation Repository can be accessed in the process modelling tool. The innovation portal from component one, for example, can be added to the innovation process in different predefined configurations using the templates described in Section 7.2.4.3. Furthermore, we defined a dummy thinkLet named "external" as a place holder for innovation phases that are not handled by the system such as implementation performed by an outsourcing partner. The screenshot

Parameter	*Possible Value*	*Description*
`systemID`	*integer*	Identifier of the innovation portal this configuration applies to.
`ideasPerPage`	*integer*	Defines how many ideas are shown per page. 0 disables paging and all ideas are displayed on one page.
`comment`	true | false	Enables or disables commenting of ideas.
`toolbox`	true | false	Enables or disables the display of the toolbox that contains the idea edit and communication buttons (e-mail and Skype).
`addNew`	true | false	Enables or disables submission of new ideas.
`search`	true | false	Enables or disables the display of the search box.
`sort`	true | false	Enables or disables the display of the sorting options (by popularity, by date, etc.).
`rating`	false | 5star	Enables or disables the 5star rating mechanism.

Table 7.5: *Summary of system configuration variables.*

Template	*Configuration Values*	*Description*
Diverge	`addNew=true` `comment=false` `rating=false`	A basic brainwriting configuration allowing idea submission only.
Refinement	`addNew=false` `comment=true` `rating=false`	This configuration focuses on refinement and extensions of existing ideas.
Converge	`addNew=false` `comment=false` `rating=5star`	Configuration for an idea selection phase.
Combined	`addNew=true` `comment=true` `rating=5star`	A traditional community configuration allowing idea submission, refinement through comments, and idea evaluation at the same time.

Table 7.6: *Summary of configuration templates for the innovation portal.*

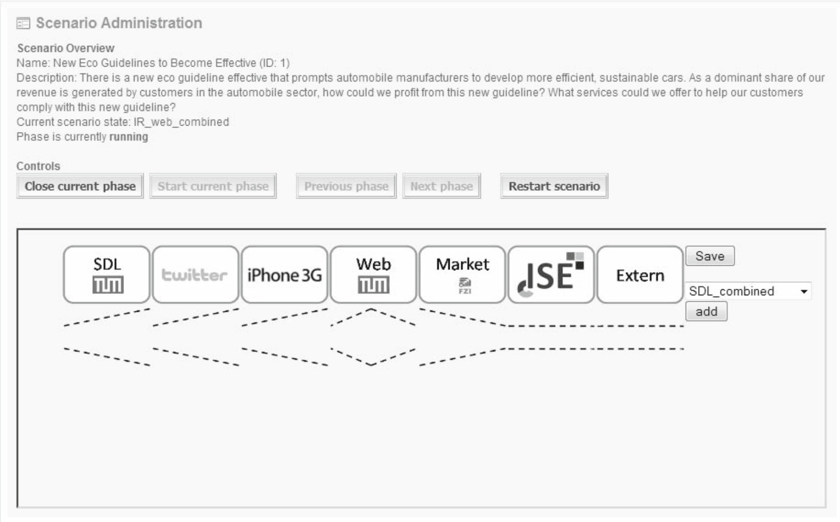


Figure 7.21: *TEXO Innovation Repository: Scenario Admin portlet.*

in Figure 7.21 shows a sample innovation process using some of the thinkLets developed in this work with combined support for diverging and converging innovation phases. In the process modelling tool each thinkLet is represented by an icon and an indicator for the type of the innovation phases supported.

The character of each thinkLet is indicated graphically by a schematic innovation funnel beneath the icon (Table 7.7). Some thinkLets support diverging innovation phases where more ideas are generated (depicted by an opening funnel), others support converging innovation phases where the number of ideas is reduced through idea rating and selection (depicted by a narrowing funnel). Some thinkLets also support combined activities that allow the combination of diverging and converging phases such as the innovation portal from component one. Furthermore, there are thinkLets that do not change the number of ideas such as implementing an idea in the service engineering phase. After refining the innovation process the innovator can persistently store the process by clicking on the "save" button. It has to be noted that a single thinkLet can be used multiple times within the same innovation process. This is useful for those tools that can be used in different configurations such as the innovation portal from component one. For example, the portal can be configured to support a diverging innovation phase (through submission of new ideas and comments) as well as a converging innovation phase (through idea ratings and disabled idea and comment submission). The tool can then be used in an innovation scenario in these two different configurations represented by two thinkLets.

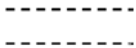
Innovation Funnel	*Description*
	A diverging innovation phase. More ideas are generated.
	A converging innovation phase. The number of ideas is reduced (i.e., through the use of rating and selection mechanisms).
	A combined innovation phase. This phase uses both diverging and converging activities.
	A neutral innovation phase. The number of ideas is not changed. This is, for example, the case in the service engineering phase when a number of selected ideas are being implemented.

Table 7.7: *Types of innovation funnels.*

7.2.4.5 Use Case: Innovator - "Control Process Execution"

In addition to defining the innovation process itself, the innovator is also responsible for controlling the execution of the process. This implies in particular moving ideas between individual phases and making the final evaluation decisions. The TEXO Innovation Repository supports this functionality through a set of system interfaces which can be used to move ideas between innovation phases. However, the invocation of these decisions and transfers has to be performed manually by the innovator. This use case describes the process execution of an innovation scenario. The process execution controls are visible above the innovation process in Figure 7.21 of the Scenario Admin portlet. Table 7.8 gives an overview of all process control elements.

Controlling the process execution serves two purposes. First, a global pointer to the current state in the innovation phase becomes available. This serves as a general progress indicator. Second, the process execution provides access to the current innovation activity and thus makes the TEXO Innovation Repository the single point of access for all innovation related activities. Using the process execution, users accessing the TEXO Innovation Repository are automatically forwarded to the URL of the thinkLet that is currently running/active (e.g., a prediction market where ideas can be traded).

7.2.4.6 Use Case: Innovator - "Define Evaluation States"

Related to the configuration of the innovation scenario itself, the scenario owner defines evaluation states ideas can be in. This allows the integration of the innovation repository into existing innovation processes within an organisation. Evaluation states are directly modelled in the Idea Ontology using instances of the `im:State` class using an

Action	*Description*
Start Current Phase	The scenario owner can continue a stopped phase to set the scenario active.
Close Current Phase	The scenario owner can stop a currently running scenario, i.e., set the scenario inactive.
Next Phase	The scenario owner can finish the current phase and advance to the next one.
Previous Phase	The scenario owner can interrupt the current phase and go back to the previous one.
Restart Scenario	The scenario owner can restart a scenario in case the present development is not satisfactory.

Table 7.8: *Process execution control elements for the innovator role in the Scenario Admin portlet.*

State	*Description*
New	A new idea. This state is used for ideas that have been newly entered in the current phase and have not been evaluated yet.
Transition	Idea that is currently being processed in the current phase. For example, an idea that is currently being implemented in a software engineering phase would have this state.
Failed	A rejected idea.
Success	A successful idea. For example, the winning idea of a prediction market would be evaluated as "success" and could then be moved to the next phase for implementation.

Table 7.9: *Sample evaluation states modelled in the demo system.*

ontology modelling tool such as Protégé (see Idea Ontology description in Chapter 6). The screenshot in Figure 7.22 depicts the modelling of evaluation states using Protégé.

Based on our analysis of the status models commonly used in innovation portals (cf. empirical analysis of innovation portals in Table 6.2), we defined the following evaluation states for our demonstration system (Table 7.9). The sample states are modelled according to a simple innovation management process that allows tracking the status of ideas. Using this modelling approach, additional evaluation states can be added to the ontology at runtime. As we are using a Semantic Web approach based on the Idea Ontology, additional features become available. In particular, the evaluation states can be organised in subclasses which become automatically available in the TEXO Innovation Repository through reasoning. For example, a special case of a "failed" idea such as "already implemented" could be added as a sub-class of the more generic "failed" class. Browsing all "failed" ideas in the TEXO Innovation Repository would then automatically return all "already implemented" ideas as well.

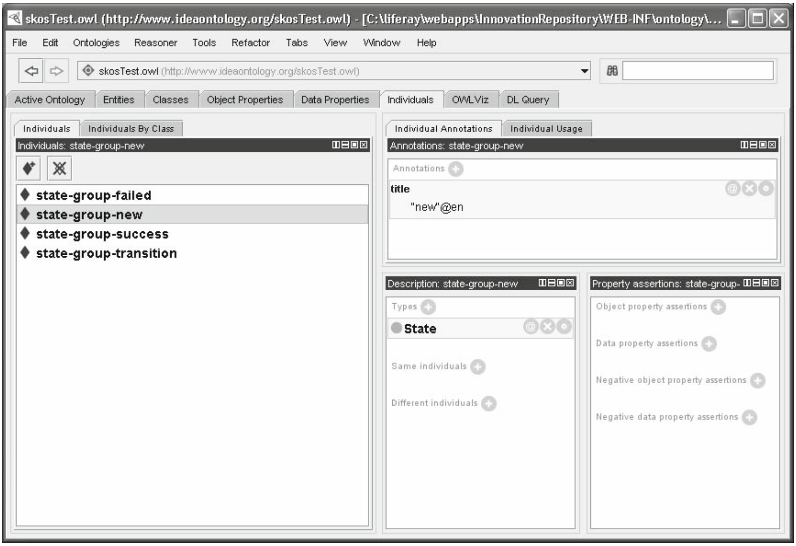


Figure 7.22: *Modelling evaluation states in the Idea Ontology using Protégé.*

7.2.4.7 Use Case: Innovator - "Manage Ideas"

The Idea Administration portlet is the main tool for innovators. It shows information about ideas currently present in the TEXO Innovation Repository and allows the modification of their evaluation and process status. The portlet provides a summary of the innovation process and indicates how many ideas are currently present in each phase (Figure 7.23). The process diagram also uses the innovation funnel icon to indicate the character of the phase (see Table 7.7). In addition, two line diagrams show the number of ideas, attachments, comments, and ratings per phase (only one line diagram is shown in Figure 7.24). Two separate diagrams are used because the number of ideas and attachments, and the number of comments and ratings usually vary by orders of magnitude, which makes the resulting diagram hard to read if the information is integrated into a single diagram. A bar diagram indicates the share of ideas per evaluation state (Figure 7.25). In the sample configuration shown in the screenshot the four states "new," "transition," "success," and "failed" introduced in Table 7.9 are visible. It is therefore possible to quickly evaluate how many ideas of a given phase already reached a certain level of maturity which is an important indicator to decide how the overall innovation scenario should progress.

In addition to aggregated management information, the Idea Administration portlet also offers key functions to manage the execution of the innovation process. Innovators are able to manage ideas by moving them between workflow phases, changing their evaluation status, or deleting them (Figure 7.26). The display of ideas is first organised by workflow phase then by evaluation state. Ideas within one particular workflow phase can be selected by clicking on the thinkLet icon in the process chain at the top of the screen. Within a particular thinkLet, ideas are then organised by evaluation states using tabs ("card

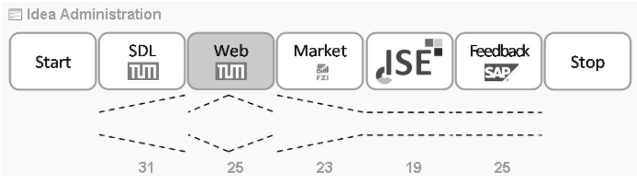


Figure 7.23: *TEXO Innovation Repository: Idea Admin portlet. Innovation process and number of ideas per phase are displayed ("Web" phase selected).*

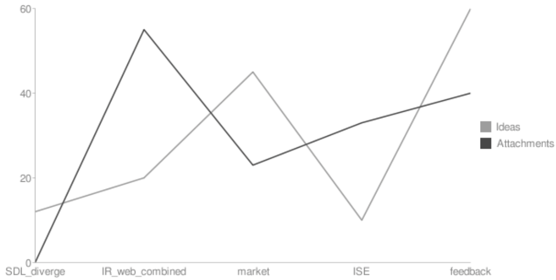


Figure 7.24: *TEXO Innovation Repository: Idea Admin portlet. Line diagram - ideas and attachments per phase.*

Figure 7.25: *TEXO Innovation Repository: Idea Admin portlet. Bar diagram - distribution of evaluation states per phase.*

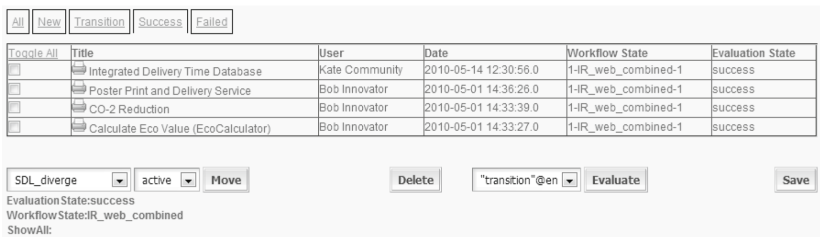


Figure 7.26: *TEXO Innovation Repository: Idea Admin portlet. Process control elements. The ideas of the selected phase and the selected evaluation state are displayed. Ideas can be selected and then (1) moved to a different phase of the innovation process (left); (2) deleted (centre); (3) the evaluation state can be changed (right).*

Figure 7.27: *TEXO Innovation Repository: GroupSystems Importer. Importing ideas from workshop.*

stack" pattern, Tidwell, 2006). An additional "all" tab is provided to access all ideas in the repository across all workflow and evaluation states. Through the use of the check-boxes the selected action can be applied to a single idea or to multiple ideas ("bulk operations" pattern, Tidwell, 2006).

7.2.4.8 Use Case: Innovator - "Import Ideas from Workshop"

Not all activities in an innovation process are performed through Web-based community tools. Group support systems play a central role in collocated workshop settings. One widely used commercial group support system is GroupSystem's ThinkTank[5] software. ThinkTank is an electronic brainstorming software package that allows systematic, tool-supported idea generation using the brainstorming technique in same-time, same-place workshop formats. To provide support for innovation activities organised in a workshop setting, we chose to integrate the ThinkTank tool. This functionality is implemented by the GroupSystems Importer portlet. Innovators can create and conduct interactive innovation workshops using the ThinkTank software. Following a workshop, the results can be exported as a Microsoft Excel spreadsheet which can then be imported into the TEXO Innovation Repository through the GroupSystems Importer portlet. As described earlier, in order to support the complete service life-cycle it is important to track the sources of ideas throughout the innovation process. For that purpose the `im:Origin` class has been introduced to the Idea Ontology. This feature of the ontology is used to attach the name of the workshop to the imported ideas. Figure 7.27 shows the portlet to import a GroupSystems file. Using the GroupSystems importer, innovation workshops are tightly integrated into the TEXO Innovation Repository.

7.2.4.9 Summary of REST API Functions

In addition to the front-end use cases described above, there is also back-end functionality that allows other systems to interact with the TEXO Innovation Repository. These systems use the REST API described in Section 7.2.3.2. Four main functions are provided: reading ideas, adding ideas, updating ideas, and special-purpose functions for the integration of specific applications. The XML-based exchange model presented in Listing 7.1 is used by the TEXO Innovation Repository both to read data from other tools and

[5] `http://www.groupsystems.com` (last accessed 2010-10-26)

Function	*Request Parameter*	*Description*
`getAll`	*none*	Returns all ideas in chronological order.
`getIdea`	`ideaID`	Returns a single idea identified by a given `ideaID`. Sample value: `1234`.[6]
`export`	`requestID`	Returns all ideas marked for export to a specific system. The example value `1-prediction-1` would return all ideas from scenario 1, in the phase "prediction" with activity state "1" (i.e., active).
`addIdea`	*idea xml* (POST)	An idea in the exchange format specified above is sent as HTTP POST request to the `addIdea` interface. The function returns 1 on success 0 otherwise.
`updateIdea`	*idea xml* (POST)	The idea data in the exchange format is passed as the body of the HTTP POST. The idea needs to contain an `ideaID` indicating which idea to update.
`addSearchSpace`	*idea xml* (POST)	Adds a search artefact to a given idea. A search artefact is passed in the search artefact exchange format (Listing 7.2).
`addIdeaRealization`	*idea xml* (POST)	Adds a service realisation to a given idea (Listing 7.3).
`importPrediction MarketResults`	*idea xml* (POST)	Imports final trading results from a prediction market. Multiple ideas can be passed (Listing 7.4).

Table 7.10: *Summary of REST API functions.*

to return data. Table 7.10 summarises the REST interfaces implemented and Table 7.11 provides additional details regarding the individual data fields. The REST APIs provide fundamental functionality for achieving the "open-ended" and "open platform" aspects of the Integrated System Design and are designed to satisfy requirement C5 (Section 3.5.4). The following use cases explain the reading, adding, and updating functions, as well as specialised REST functions that use additional fields in the idea exchange format.

7.2.4.10 Use Case: System - "Exchange Ideas"

To read ideas from the TEXO Innovation Repository we implemented three different REST functions: `getAll` to read the complete idea pool, `getIdea` to read a specific idea identified by an `ideaID`, and a workflow-oriented `export` function (see Table 7.10). The `export` function is similar to the `getAll` but returns only ideas from a specific workflow phase. This function is used, for example, to export ideas to a prediction market tool, i.e., all ideas that have been moved to the prediction market phase using the Idea Admin portlet described in Section 7.2.4.7. Thus, the export function provides a

[6] Using localhost:8080 as an example the resulting URL is `http://localhost:8080/InnovationRepository/getIdea?ideaID=1234`

Tool	*Field*	*Description*
Search Artefact	ID	The identifier under which the search artefact is stored in the Innovation Mining Cockpit.
	Title	A title to describe the search artefact.
	Author	The author of the search artefact.
	Description	A short description giving more details about the stored search artefact.
	Link	An "open" link that loads the attached search artefact in the Innovation Mining Cockpit.
Market Results	Name	The name of the market.
	Trading start	Time when the trading started (date and time).
	Trading stop	Time when the trading ended (date and time).
	List: idea and price	The general information about the market is followed by a list of all the ideas that have been traded in this market and their resulting final prices sorted by price (i.e., the most successful idea stands on top). The titles of ideas traded in the market are displayed as links which allows navigation to those ideas.
Idea Realisation	Name	The name of the service implementation.
	Link	An "open" link that loads the attached idea realisation in the AGORA market place.

Table 7.11: *Data fields available in the front-end integration of other TEXO tools on the idea detail page.*

process-oriented integration of special-purpose applications. While the reading functions are simple HTTP GET requests, the `addIdea` and `updateIdea` functions implement the HTTP POST function instead. Thus, to add an idea, a system can perform an HTTP POST call to the TEXO Innovation Repository. The format of the POST data again follows the exchange format specified above. The update function is similar to the function for adding ideas but an `ideaID` is required to indicate which idea is updated.

7.2.4.11 Use Case: System - "Add Search Artefact"

The *Innovation Mining Cockpit*, a specialised Web-search tool, developed by TEXO partner Fraunhofer IAO (cf. Finzen et al., 2009) can be used to discover trends by systematically searching the Internet for innovation relevant data. One key feature of this cockpit is that search spaces can be manually configured and searches can be saved to be re-run at a later time. Using the integration with the TEXO Innovation Repository these search artefacts (saved searches, configured search spaces) can be "attached" to an idea using a REST function (Listing 7.2). In the front-end of the Innovation Mining Cockpit, the `getAll` function is first called to present the user with a list of all ideas in the repository. The user can then choose an idea to attach the search artefact to. The search artefact is then attached to the chosen idea via the `addSearchSpace` API function. Irrespective of the Innovation Mining Tool, this feature demonstrates how the Idea Ontology can be extended in a flexible way by adding new fields and features to an idea.

7.2.4.12 Use Case: System - “Add Idea Realisation”

In order to support the full service life-cycle (cf. requirement C1) it is necessary to store persistent links between an idea and the resulting implementation of that idea. For that purpose the `im:IdeaRealization` class has been added to the Idea Ontology (Chapter 6). Using the `addRealization` REST function it is possible to attach a service implementation to a given idea (Listing 7.3). The idea realisation is implemented as a $n : m$ relationship so that multiple service realisations can be added to an idea and a single service can implement multiple ideas. The URL provided for the idea realisation is then used for front-end integration (Section 7.2.4.14). This function is used to link ideas to their respective service implementation in a service market place or service runtime environment (e.g., SAP’s AGORA market, Cardoso et al., 2010).

7.2.4.13 Use Case: System - “Import Ideas from Prediction Market”

Once ideas have been traded in a prediction market, the resulting ranking and final prices of the traded ideas have to be written back to the repository. Because the ideas in a prediction market are traded against each other, the results do not provide an absolute evaluation of an individual idea but a relative ranking against other ideas. Consequently, it is necessary to store not only the final price of any traded idea but also against which other ideas it has been traded in a market. The ideas traded against each other in a prediction market are identified by a `marketID` (Listing 7.4).

7.2.4.14 Front-End Integration

This prototype component implemented the TEXO Innovation Repository as an open platform that allows the integration of external applications, in particular those developed by other partners of the TEXO project. In addition to the integration on the data layer in the back-end (cf. previous use cases of the REST API), integration in the innovation portal provided by component one is also available. This offers an additional front-end use case for the community member role implemented in component one (Section 7.1). Through the front-end integration community members can directly access other TEXO tools via a set of icons on the overview page (Figure 7.28 and Table 7.12).

These icons are displayed in addition to the icons for editing and messaging (e-mail and Skype) in the toolbox to the right of an idea (see Section 7.1.4.1). Using these icons, community members can identify additional information available for an idea. On

```xml
<?xml version="1.0" encoding="UTF-8"?>
<ideas>
        <idea>
                <ideaID>[ideaID]</ideaID>
                <searchSpaceID>[search artefact ID]</searchSpaceID>
                <searchSpaceTitle>[artefacttitle]</searchSpaceTitle>
                <searchSpaceAuthor>[first, last]</searchSpaceAuthor>
                <searchSpaceURL>
                        http://[innoMiningTool]/?searchSpaceID=[ID]
                </searchSpaceURL>
        </idea>
</ideas>
```

Listing 7.2: *Adding a search artefact to an idea via the REST API.*

```xml
<?xml version="1.0" encoding="UTF-8"?>
<ideas>
        <idea>
                <ideaID>[ideaID]</ideaID>
                <serviceID>[serviceID]</serviceID> <!-- ID in AGORA -->
                <serviceURL>[URL in AGORA]</serviceURL>
                <serviceDescription>[description]</serviceDescription>
        </idea>
</ideas>
```

Listing 7.3: *Adding a service realisation to an idea via the REST API.*

```xml
<?xml version="1.0" encoding="UTF-8"?>
<ideas>
        <idea>
                <ideaID>[ideaID]</ideaID>
                <marketID>[marketID]</marketID>
                <marketTitle>[market title]</marketTitle>
                <tradingStart>[date time]</tradingStart>
                <tradingStop>[date time]</tradingStop>
                <finalPrice>[price float]</finalPrice>
                <marketURL>[market URL]</marketURL>
        </idea>
        [...]
</ideas>
```

Listing 7.4: *Importing final trading prices from a prediction market.*

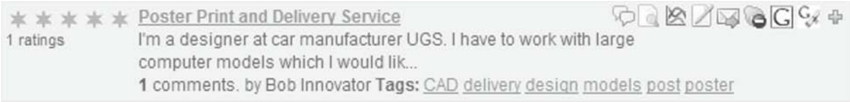


Figure 7.28: *TEXO Innovation Repository: sample idea display in the front-end. The toolbox to the right shows additional control icons for front-end integration.*

the detail page of an idea, additional information that becomes available through the integration is displayed (Figure 7.29).

Symbol	*Description*
	This idea has been traded in a prediction market. Market ranking information is available on the detail page of this idea.
	A search artefact in the Innovation Mining Cockpit is attached to this idea. A link to the search artefact as well as additional information is available on the detail page of this idea.
	An idea realisation is attached to this idea. A link to the respective service implementation in the AGORA market place as well as additional information is available on the detail page of this idea.

Table 7.12: *Symbols used for the integration of other TEXO tools in the toolbox of an idea.*

Figure 7.29: *TEXO Innovation Repository: detail information available through front-end integration. The screenshot shows an idea with an attached search artefact, market results, and an implemented idea realisation.*

7.2.5 Artefact Evaluation

Documenting experiences of the system development process is a fundamental part of design research (Nunamaker/Chen/Purdin, 1991; Hevner et al., 2004). This section makes an important contribution to the body of knowledge by presenting newly learned design principles that can guide future developments of similar systems. During the system implementation of component two we discovered several additional requirements for our initial system design presented in Chapter 5. The first part of the evaluation section thus focuses on documenting these experiences. The second part presents an evaluation of our claim of the TEXO Innovation Repository to be an open platform by presenting how we were able to integrate several special-purpose applications into the central repository.

During the implementation of component two, we realised that we needed a more flexible way to work with multiple installations of the TEXO Innovation Repository. Through the project structure and the experiments we wanted to perform it became obvious to us that the original design from Section 5.4 was too limited. In particular, we needed the ability to set up multiple instances of the TEXO Innovation Repository, all with different configurations and look-and-feels (for example, a demo system and another system for running an experiment). In a major redesign of the fundamental architecture we changed the TEXO Innovation Repository to a more flexible multi-tenant architecture. Our multi-tenant architecture is described in Sections 7.2.5.1 and 7.2.5.2. Furthermore, we realised that we needed support for additional languages. Section 7.2.5.3 describes our concept for supporting multiple languages which is tightly integrated into the multi-tenant architecture. The description of these changes made to the original system design following extended usage and evaluation constitutes the first part of this evaluation section.

In the second part of this evaluation section, we present two integration scenarios with two special-purpose applications. First, Section 7.2.5.4 presents the integration of Apple's iPhone as a special-purpose application supporting mobile devices. Second, Section 7.2.5.4 presents the integration of Twitter as an application related to social networks. The two integration scenarios demonstrate the ability to integrate external applications with the TEXO Innovation Repository and thus substantiate our claims of the TEXO Innovation Repository to be an open platform. The summary in Section 7.2.5.8 finally presents a complete list of external applications that have been integrated into the TEXO Innovation Repository as well as the data mapping of the external applications on the Idea Ontology.

7.2.5.1 Multi-Tenant Architecture

This section describes the new design principle "multi-tenant architecture" that we devised during the development of component two. The multi-tenant architecture presents an extension of the Integrated System Design presented in Chapter 5. During the development and initial experiments we faced a central problem: we needed multiple set-ups of the repository for different use cases. For example, to have different configurations of the system for the treatment and the control group of an experiment. We also needed different set-ups with regards to language, look-and-feel, and configurations for development, demonstrations, and field studies. To provide multiple instances of the TEXO Innovation Repository we implemented a multi-tenant architecture. In the context of software architecture, multi-tenancy refers to an architectural design where a single instance of the software runs on a server, serving multiple client organisations (tenants) (Chong/Carraro/Wolter, 2006). Multi-tenancy is contrasted with the traditional multi-instance architecture where separate software instances (sometimes including separate hardware systems) are set up for different client organisations. Using a multi-tenant architecture, the software application is designed to virtually partition its data and configuration such that each client organisation works with a customised virtual application instance. The multi-tenant architecture has several benefits over the multi-instance architecture. First, it substantially saves resources as multiple clients can be served through a single virtual system (e.g., only one application server installation is necessary). Second, it simplifies application maintenance as only a single instance needs to be maintained and updated. Upgrades are performed on a centralised server and all clients can automatically access the new version. Thus, the multi-tenant architecture also improves the TEXO Innovation Repository's generativity regarding easy upgrade paths (cf. generative design directive D9 in Section 4.4).

Our multi-tenant architecture builds on basic functionality provided by the Liferay portlet container (see Section 7.2.4.1) but substantially extends it with additional functionality. Figure 7.30 depicts the multi-tenant architecture of the TEXO Innovation Repository. Key feature of the multi-tenant architecture is the ability to create multiple Liferay instances and communities from a single Liferay installation and a single installation of the TEXO Innovation Repository. Multiple instances of the TEXO Innovation Repository identified by unique URLs work side-by-side accessing a single code base and master data object. The master data object in turn contains a reference to each tenant's individual system configuration. The multi-tenant architecture is also reflected in the persistent data storage. Here, an additional field indicating the tenant a data entry belongs to is added to every entry. Table 7.13 shows a sample database table for idea records for multiple tenants (identified by `systemID` column). Thus, each tenant has its own private data pool which is not visible to other tenants.

The new multi-tenant architecture results in a new overall process for the management of the TEXO Innovation Repository (Figure 7.31). Following this management process allows the convenient setup of experiment environments with individual configurations.

7.2.5.2 Use Case: Community Member - "Display Scenario"

Through the multi-tenant architecture the innovation context of an innovation portal (component one) is no longer unambiguous as multiple instance of the TEXO Innovation Repository exist for multiple tenants. Therefore, we added the Scenario Home portlet to the community member home screen. It displays a short scenario description to inform a community member about the aim of the current scenario. The portlet displays a simple introductory text that can be added at the top of the innovation portal homepage. The scenario description `Scenario::description` of the thinkLet implementation is used for this purpose (Section 7.2.3.1). Figure 7.32 shows a sample scenario description.

7.2.5.3 Internationalisation

For the prototype developed in this work a set of different evaluations (presentations to collect feedback, field studies, and experiments) have been planned. These applications of the TEXO Innovation Repository are targeted at different user groups ranging from industry partners to students. To support the linguistic demands and abilities of the respective groups, the prototype had to be internationalised. That means that the prototype had to be available in different languages, in particular, in English and German.

On a technical level, internationalisation has been implemented using standard Java internationalisation technique (without author, 2010b): all language elements have been removed from the Java code and have instead been added to a separate properties file for

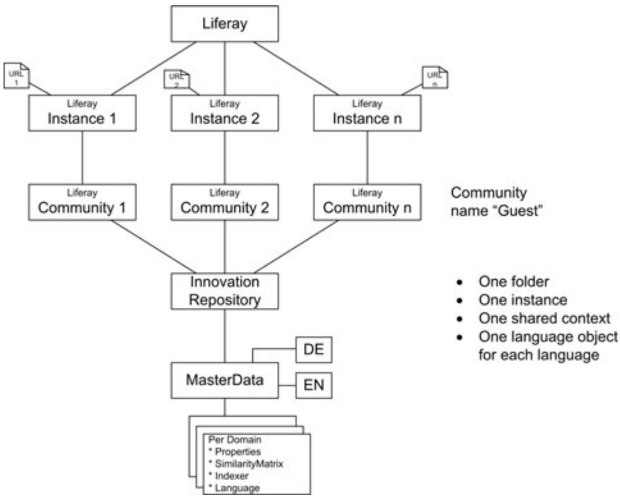


Figure 7.30: *Multi-tenant architecture.*

systemID	ideaID	title	created	createdBy
3	4719	Dynamische Suche in SAP	2009-11-02 15:35:42	16073
2	4842	Offer packets of Stevia as a sweetener	2009-11-15 14:06:46	15849
2	4843	Recycle in stores now	2009-10-01 14:06:46	15849
4	4894	SAP-Demoserver	2009-11-01 15:29:37	16073
5	4943	SAP-Demoserver	2009-11-01 15:29:37	16073
1	4976	Calculate Eco Value (EcoCalculator)	2009-09-28 10:45:35	17302
6	5053	Arztadressen austauschen	2009-11-01 15:29:37	16353

Table 7.13: *A sample table with a collection of ideas for different tenants (column systemID).*

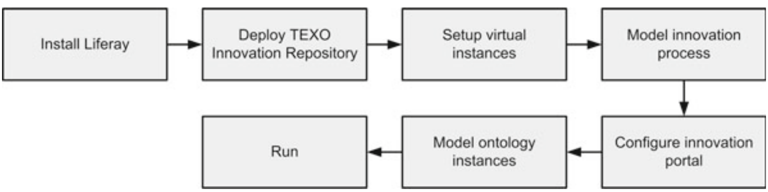


Figure 7.31: *Management process of the multi-tenant environment.*

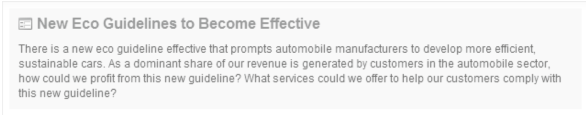


Figure 7.32: *TEXO Innovation Repository: Scenario Home.*

Figure 7.33: *TEXO Idea iPhone client. (Left) The TEXO Idea icon on the iPhone home screen. (Right) The client to post ideas.*

each language. The properties file contains key-value pairs mapping an identifier (key) to a localised string (value), e.g., “safeButton = speichern.” On the application layer it is then only necessary to specify which property file should be used to read the corresponding language mappings. This was achieved by introducing an additional configuration variable `language` which can be adjusted in the System Admin portlet (Section 7.2.4.3).

This internationalisation has then been added to the multi-tenant architecture in the following manner. There exists a global language object, read from its own properties file, for each language that the system supports (English (en-US) and German (de-DE)). Each tenant’s master data object then offers a reference to one language object as specified in the tenant’s system configuration (e.g., `language=en`). Thus it is possible to configure the language of each instance of the TEXO Innovation Repository individually without the need to adjust the general installation of the system (Figure 7.30).

7.2.5.4 Integration Scenario One: iPhone Client

Following a scenario-based evaluation approach (Johnson/Russo, 1991; Bosch et al., 1999), this section presents the integration of an external application. The aim of this integration scenario is to demonstrate the integration process itself and support our claims that the TEXO Innovation Repository presents the successful implementation of an open-ended system. Due to the increased importance of mobile devices (Capps, 2009; Roman, 2010) we chose the integration of the Apple iPhone.

The aim of the iPhone application is to allow users to submit ideas via their mobile devices. This addresses the needs of increased mobility and allows users to record ideas wherever they occur. The simple tool facilitates the submission of sudden inspirations and therefore leads to an increase in potential innovations present in the repository. Moreover, the mobile client is used to further demonstrate the repository character of the TEXO Innovation Repository and is intended to highlight the flexible integration of external innovation tools. Thus, it is possible to integrate special-purpose applications into an innovation process to support a variety of complex scenarios.

Figure 7.34: *Geoinformation attached to an idea posted using the iPhone client is displayed using Google Maps (Source: Google Maps).*

The TEXO Idea iPhone client uses the REST function `addIdea` to send ideas to the repository. The client itself is implemented as a “Web App.”[7] The application can be added to the home screen which makes it accessible as a stand-alone application. Ideas posted using the iPhone client can, if enabled by the user, submit GPS location information, which is attached to the idea. This allows analysing ideas with regard to their posting location to identify highly creative “spots” (e.g., the coffee corner of an organisation) or innovation clusters in general (e.g., the areas around the Silicon Valley). In case geoinformation is attached to an idea, the location is displayed on the idea details page (Section 7.1.4.3) using the Google Maps API[8] (Figure 7.34). In summary, the iPhone integration scenario shows how the existing REST API can be leveraged to access the TEXO Innovation Repository with external applications and thus extend the repository's range of interfaces without additional implementation efforts.

7.2.5.5 Integration Scenario Two: Twitter Client

To demonstrate a slightly more complex application integration, we chose to integrate the social networking platform Twitter.[9] Twitter is a micro-blogging service on the Internet where blog entries, so called *tweets*, are limited to 140 signs. The aim of the TEXO Idea Twitter client is to allow posting of ideas to the repository through Twitter, i.e., a tweet using the topic identifier “#idea” should be read by the repository back-end and copied to the local idea pool. Contrary to the iPhone scenario, this does not represent integrating a new front-end application with the repository, but integrating an additional back-end application which reads entries from Twitter and copies them to the repository. As front-end interface, any standard Twitter interface can be used (Figure 7.35).

To implement this back-end application we created a system daemon running in the background. The daemon connects to the global stream of Twitter feeds in regular intervals to read new entries. To specify which entries to read the Twitter API provides a timestamp function, the `sinceID`. This `sinceID` is passed with the API call reading data from Twitter and all tweets newer than the given `sinceID` are returned. In addition to the `sinceID` the Twitter API also demands a user name and password to ensure only registered applications can access the tweets. After making a call to the Twitter API, the

[7] `http://developer.apple.com/` (last accessed 2010-10-26)
[8] `http://code.google.com/apis/maps/` (last accessed 2010-10-26)
[9] `http://twitter.com/` (last accessed 2010-10-26)

Parameter	*Possible Value*	*Description*
`TwitterUID`	*string*	The user ID of the account registered for the application with Twitter.
`TwitterPass`	*string*	The password of the Twitter account.
`TwitterSinceID`	*timestamp*	The Twitter since ID returned with the last API call.
`TwitterLiferayUID`	*numeric*	The user ID of a Liferay user account under which the tweets should be stored.

Table 7.14: *Configuration values for the TEXO Idea Twitter client.*

TEXO Idea Twitter client stores the new `sinceID` which is then used in the next API call. All tweets returned are transformed by the daemon into idea objects and added to the repository using the standard REST function `addIdea`. As the TEXO Idea Twitter client is intended as an open input interface, ideas are added to the repository under a dedicated Twitter user name rather than the user name of the tweet's author which is unlikely to correspond to any user name registered with the TEXO Innovation Repository. Overall, the TEXO Idea Twitter client needs to be configured using four additional configuration values (Table 7.14). The configuration itself is performed using the System Admin portlet (Section 7.2.4.3). In summary, the TEXO Idea Twitter client allows users to be generative in more places by posting ideas on Twitter using the "#idea" token. The ideas are then automatically copied to the repository. While the TEXO Idea iPhone client shows the integration of an additional user interface through the REST API, the TEXO Idea Twitter client demonstrates the integration of an additional back-end application. As Twitter itself can be accessed through a variety of interfaces (Web and mobile clients) the TEXO Idea Twitter client adds a multitude of user interfaces to the TEXO Innovation Repository despite being a daemon application running in the background.

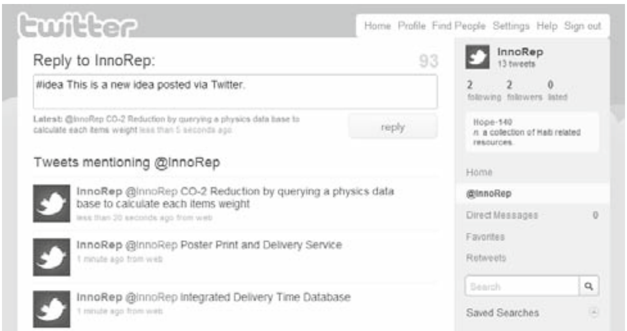


Figure 7.35: *TEXO Idea Twitter client. Posting ideas using Twitter (Source: Twitter.com).*

7.2.5.6 Summary of Integrated Systems

As mentioned in the introduction, this research is part of the THESEUS/TEXO research project. This project setting provides additional evaluation opportunities by integrating

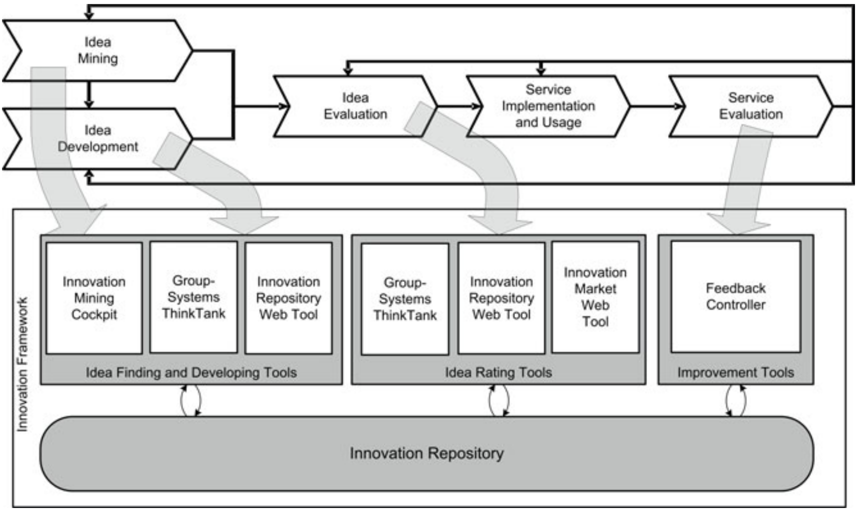


Figure 7.36: *Innovation framework and system architecture of the TEXO project (adapted from Riedl* et al.*, 2009c).*

special-purpose applications developed by project partners. This section provides some additional background regarding the TEXO project and the special-purpose applications that have been integrated with the TEXO Innovation Repository.

The TEXO project investigates how services, in particular electronic services, can be made tradeable and composable through a business value network. To harness the innovative capabilities present in the resulting business networks (Riedl et al., 2009b; Riedl et al., 2009a), a cyclic innovation process consisting of several innovation steps is used in TEXO (Stathel et al., 2008; Riedl/Leimeister/Krcmar, 2010). The resulting innovation framework methodologically and technically connects different tools and methods for systematic idea development. Figure 7.36 illustrates the innovation framework, aligning the innovation system architecture with the innovation process. After an idea has been created and developed using tools such as the Innovation Mining Cockpit (Stathel et al., 2008; Finzen et al., 2009), workshops using electronic group support systems such as GroupSystem's ThinkTank software (Section 7.2.4.8), or a Web-based community platform (Section 7.1), the idea is evaluated using a prediction market approach (Stathel et al., 2008; Stathel/van Dinther/Schönfeld, 2009). Such an evaluation using virtual stock markets may be superior to evaluations by experts as they incorporate information held by a variety of people (Surowiecki, 2005; Spann et al., 2009; Dahan/Soukhoroukova/Spann, 2010). If the evaluation result is positive, the idea is implemented using a service engineering environment, the ISE Workbench. Finally, the implemented service is used on the AGORA service market place (Cardoso et al., 2010). Service usage information improves existing services using the Service Feedback Controller.

Table 7.15 summarises all tools that have been integrated in the TEXO Innovation Repository. Through the additional front-end integration of the tools (Section 7.2.4.14) the innovation portal provides a convenient single point of access for all innovation related information. Innovation relevant data is centred on the concept of an "idea" which avoids scattered and inaccessible data spread across a myriad of innovation tools. By using an "idea" as entry point, all data associated with that idea can be directly accessed independently of the tool in which this data has been generated.

7.2.5.7 Component Two as Evaluation of the Idea Ontology

The prototype implementation of component two instantiates the Idea Ontology developed in Chapter 6. It provides an important proof-of-concept that demonstrates the feasibility of an innovation management tool using Semantic Web technology based on the Idea Ontology. In addition to the general proof-of-concept we engaged in a formal architectural analysis to evaluate the design of the Idea Ontology. In an architectural analysis one studies the fit of an artefact with the technical architecture of the overall information system (Hevner et al., 2004). The application demonstrates the effects of the ontology on a complex innovation management scenario. It further presents a sophisticated innovation process in which the ontology may be utilised to leverage the existing capabilities of the tools employed by resolving interoperability issues. This allows technical integration of various specialised tools that are designed to support the various idea generation and evaluation tasks. The special-purpose tools presented above can be used simultaneously by different teams or even organisations. The Idea Ontology explicitly enables collaboration by means of capturing the application (as `im:Origin`) that is the source of an idea. Through the use of the Idea Ontology we were able to integrate the different tools developed in the TEXO project with the TEXO Innovation Repository. To demonstrate the completeness of the integration Table 7.16 shows how the data fields of each of the tools can be mapped onto the Idea Ontology.

7.2.5.8 Summary of Evaluation

The first part of the evaluation section presented our design for a multi-tenant architecture which resulted from our experiences during the development of component two. This presents a new design principle which can be used to guide future developments of similar systems. The implication for the overall system design is summarised in the following box.

> **Implications for the System Design** A multi-tenant architecture is necessary for the TEXO Innovation Repository to allow flexible system set-ups to support experimentation and evaluation. Our design proposes a new design principle how Liferay can be used to design a multi-tenant architecture.

The second part of the evaluation showed how we were able to integrate various special-purpose applications with the TEXO Innovation Repository. The Innovation Mining Cockpit, a Web-based community platform, GroupSystems' ThinkTank software, a prediction market-based idea evaluation tool, and post-implementation service evaluation using the Feedback Controller have successfully been integrated within the THESEUS/-

Symbol	*System*	*Partner*	*Description*
Feedback SAP	AGORA Service Marketplace	SAP	The AGORA marketplace provides an Internet platform on which implemented and running services can be traded and invoked. AGORA has been integrated as a feedback phase that allows deriving runtime information necessary for service improvements.
ISE	ISE Workbench	TEXO	The service engineering process of the ISE Workbench is integrated through the REST API which allows the ISE to read ideas from the repository.
Mining	Innovation Mining Cockpit	IAO	Any kind of search artefact offered by the TEXO Innovation Mining Cockpit (e.g., customised search spaces, relevant result documents or saved search queries) can be attached to ideas accessed via the Idea Portal.
Market FZI	Prediction Market	FZI	Using an virtual stock market approach ideas can be evaluated against each other in a prediction market.
SDL	GroupSystems ThinkTank	TUM-Kr	On-site innovation workshops using GroupSystems ThinkTank are fully integrated in the Innovation Repository. Thus, results from a brainstorming workshop can be refined, evaluated, and tracked using the repository.
Web	Community Front-End	TUM-Kr	A Web-based innovation portal to allow community driven idea generation and refinement (component one, Section 7.1).
iPhone 3G	TEXO Idea iPhone client	TUM-Kr	A Web-based client to allow community driven idea generation and refinement (Section 7.2.5.4).
twitter	TEXO Idea Twitter client	TUM-Kr	A back-end client integrating Twitter (Section 7.2.5.5).

Table 7.15: *Summary of tools integrated in the TEXO Innovation Repository.*

Tool	*Field*	*Mapping in Idea Ontology*
Innovation Mining Cockpit		
	Title	`im:CoreIdea/title`
	Search report	`foaf:Document` linked to an `im:coreIdea` through `hasAttachment`
	Saved search	`foaf:Document` linked to an `im:coreIdea` through `hasAttachment`
TEXO Innovation Repository Community Front-End		
	Title	`im:CoreIdea/title`
	Description	`im:CoreIdea/description`
	Author	`im:CoreIdea/hasAuthor` linked to `foaf:person`
	Status	`im:Status`
	Tags	`im:CoreIdea/hasTagging` linked to `Tags:Tagging` with additional fields: `taggedBy` a `foaf:Person` `taggedOn` a date

	Comments	`sioc:Item` linked to a `sioc:Forum` via `hasContainer`
		`sioc:Forum` linked to an idea via `hasForum`
		`sioc:Item` also linked to `skos:Concepts` via `hasTopic`

GroupSystems ThinkTank		
	Idea	`im:CoreIdea/title`
	Rating	`r:Rating` `r:value` (e.g., "1=bad") `r:assessedBy` (e.g., "brainstorming session") `r:rates` (i.e., the im:CoreIdea being rated) `r:hasRatingKind` (e.g., "usability rating")
	Comment	as above
Information Market		
	Title	`im:CoreIdea/title`
	Description	`im:CoreIdea/description`
	Trade-based idea ranking	`r:Rating` `r:value` (e.g., "99") `r:assessedBy` (i.e., an instance of the prediction market) `r:rates` (i.e., the coreIdea being rated) `r:collectedBy` (i.e., the prediction market tool) `r:hasRatingKind` (e.g., an "OverallRating")
Feedback Controller		
	Title	`im:CoreIdea/title`
	Implemented service	`hasRealization` linking to a service description in WSDL accessible under an URL
	Community	`sioc:Forum` attached to an `im:CoreIdea` `sioc:Item` for individual community posts

Table 7.16: *Mapping between tool data and Idea Ontology concepts.*

TEXO project, and interoperability has been achieved. In addition to the integration of these tools from the TEXO project, we also presented two integration scenarios of a new front-end client (iPhone) and a back-end application (Twitter). The successful integration of these external applications supports our claim that the TEXO Innovation Repository presents an open-ended platform that allows the integration of special-purpose applications. The integration of external applications is enabled by the use of the Idea Ontology. Consequently, the successful integration of these applications also constitutes an important evaluation of the Idea Ontology itself. The mappings presented in Table 7.16 demonstrates that the Idea Ontology is expressive enough to support a multitude of applications from a variety of backgrounds. Given this project context, the ontology has proven to be expressive enough to cover all relevant data fields. Through the interoperability and technical integration between tools, a better support of the idea life-cycle has been achieved as tools provide specialised support for different life-cycle functions (e.g., sophisticated idea evaluation through a prediction market approach).

7.2.6 Discussion

In component two a variety of new front-end use cases have been added to the TEXO Innovation Repository. In particular, several use cases for the innovator role that allow customising and controlling the innovation process as well as managing a large innovation pool have been added. Another innovator use case allows the convenient configuration of the general system setup, without the need to edit configuration files on the system level. Furthermore, new community member features have been added in component two. First, to emphasise the central integration character of the repository a iPhone and a Twitter client have been added that allow the use of the TEXO Innovation Repository on mobile devices and social networking platforms. Second, the integration with other TEXO tools is also reflected on the front-end through the use of additional symbols in the idea toolbox as well as additional information displayed on the detail page of an idea.

The management functions introduce a process view on the innovation scenario which allows the design and customisation of the innovation process itself as well as the execution of that process. Furthermore, using the Idea Admin portlet innovators gain a detailed outline of the ideas in the repository and their distribution across innovation phases. In addition to this statistical data, control elements allow the innovator to evaluate ideas and move them between phases. Thus, ideas can be tracked and pushed through the innovation process towards implementation. This section also showed how the advantages of the Idea Ontology can be leveraged using standard ontology modelling tools such as Protégé to define and manage evaluation criteria. This component also focused on integration aspects with the efforts of other TEXO partners. In addition to the innovation portal implemented by component one, the following tools have been successfully integrated into the TEXO Innovation Repository: AGORA Service Marketplace, ISE Workbench, GroupSystems ThinkTank, Innovation Mining Cockpit, Prediction Market, TEXO Idea iPhone client, and TEXO Idea Twitter client.

In summary, component two provides core functionality to implement the vision of a process-oriented, open-ended repository that allows the integration of special-purpose applications. It therefore addresses generativity on the technical layer by providing core functionality necessary to extend the system. The next section presents the implementation of component three which provides a specialised idea rating mechanism to support a converging innovation phase.

7.3 Component Three: Idea Rating Mechanisms

Component one provides a functionally complete innovation portal and component two provides a process-oriented, open-ended innovation portal that allows the integration of additional special-purpose tools, including the innovation portal from component one. The collection of ideas from different tools in a single repository results in large sets of ideas with similar entries from different tools. This leads to a large, unstructured dataset which is difficult to grasp and difficult to develop further due to the lack of process structure. The problem situation can be summarised as very complex due to a large amount of unstructured and redundant data. Component three extends the innovation portal with the exemplary implementation of an operational efficiency feature: a specialised idea rating mechanism. This section presents our research related to the implementation and evaluation of the idea rating mechanism. The results and analyses of this chapter are based on research reported in Riedl et al., 2010a.

In addition to realising the overall system design, our research performed for the design, implementation, and evaluation of component three makes a contribution by itself. Due to a lack of systematic study of rating mechanisms for online innovation communities this section extends previous decision management research by analysing effective idea rating and selection mechanisms in this context. Our work goes beyond published research and aims to extend kernel theories regarding the design of idea rating mechanisms in online innovation communities and thus to contribute to the scientific knowledge base. In summary, the research presented in this section serves three goals:

1. Implement an operational efficiency feature for the overall TEXO Innovation Repository that allows effective evaluation and selection of ideas for refinement or implementation. Thus, component three adds crucial system functionality to the overall TEXO Innovation Repository and helps to provide more complete tool support for innovation management in service ecosystems.

2. Contribute to the body of knowledge regarding the design of innovation portals. From a theoretical perspective, we offer insights into how different rating mechanisms for idea selection work within the context of online innovation communities. From a practical perspective, our research provides actionable design guidelines for community-based rating mechanisms in innovation portals.

3. Perform a usability test of the TEXO Innovation Repository in general, not only the idea rating mechanism. The experiment involves a large number of users who provide valuable feedback regarding the usability of the system. Furthermore, the experiment serves as a stress test of the prototype and demonstrates its fitness for

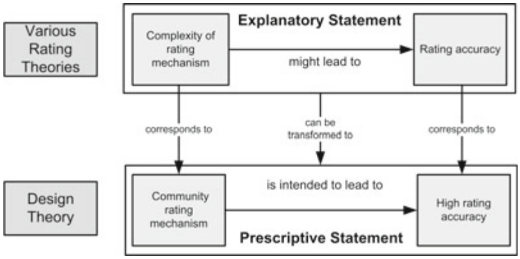


Figure 7.37: *Design theory for the third prototype component.*

use in large scale scenarios because we are only be able to collect the relevant rating data if the prototype works well and without complications.

7.3.1 Aim and Scope

Dell IdeaStorm and MyStarbucksIdea are two prominent examples of the online innovation communities collected in Table 6.2. Both comprise far more than 10,000 user-generated ideas. However, a company's absorptive capacity is limited regarding such an amount of ideas (Di Gangi/Wasko, 2009) so that there is a strong need for a mechanism to identify the best ideas. This filtering of ideas is usually achieved through some form of rating mechanism. Open innovation platforms generally use different rating scales that allow users to rate the submitted ideas. The effective design of those rating mechanisms enhances the validity and reliability of resulting idea ratings and supports the selection of the best ideas for further refinement or implementation. To date there is a lack of systematic study of how online communities can be exploited to better achieve different objectives of companies' innovation initiatives. Without such knowledge, ad-hoc use of online communities may result in inefficient resource utilisation and may impair the effective integration of external actors into the innovation process. This problem may be particularly salient with the increasing choices and sophistication of tools available for the creation of online communities.

The aim of prototype component three is to build an idea evaluation mechanism with high operational efficiency. The prototype should then provide support for better structured innovation processes and systematic idea evaluation and selection. The third component thus implements an operational efficiency feature: an idea rating mechanism which can be used by an online innovation community to evaluate sets of ideas collected in the TEXO Innovation Repository. Due to the recent development of the open innovation field, no design theory is available to guide the exact design of an idea rating mechanism in online innovation communities. The survey of online innovation portals presented in Table 6.2 alone shows six different rating methods. Therefore, we chose to implement three different rating mechanisms and evaluate them using a field experiment in order to determine which rating mechanism works best in the context of online innovation portals. Figure 7.37 gives an overview of the mapping of the cause-effect relationship on the means-end relationship for the third prototype component.

Cause-Effect On a general level, research found a strong correlation between process structure and outcome quality, as well as user satisfaction (Nunamaker/Chen/Purdin, 1991; Fjermestad/Hiltz, 2001). This leads to the use of idea rating and evaluation methods as a standard approach to implement converging innovation phases. This can be formulated as a cause-effect relationship as follows: decision-oriented task structures lead converged results. This serves as the general cause-effect relationship to guide the development of component three.

The complexity of the rating scale and its optimal number of categories are depending on the ability to differentiate a specific circumstance as well as the respondent's ability to discriminate the given circumstance (Malhotra, 2009). Research on survey design shows how the number of response alternatives affects the psychometric properties of a scale and most researchers found an increasing granularity of the scales to positively influence the reliability and the factorial validity of the measured constructs (Ferrando, 2000; King/King/Klockars, 1983; Lozano/Garca-Cueto/Muiz, 2008). As idea quality is generally considered a complex construct (Dean et al., 2006; Reinig/Briggs/Nunamaker, 2007), factorial validity is a desirable property. This can be expressed as a cause-effect relationship: increasing granularity of the rating mechanism leads to higher reliability and factorial validity of the measured idea quality. This is countered by an opposing cause-effect relationship that the higher the complexity of rating mechanism, the higher the drop-out will be (Couper et al., 2006). However, to date there is a lack of systematic study of how rating mechanisms for online innovation communities should be designed.

Means-End In the rating process, respondents act as cooperative communicators and they will endeavour to make sense of the questions by drawing on all information including formal features, such as the numeric values of rating scales or the scales' graphical layout (Schwarz, 1996). This is especially true when respondents are unsure about what is being asked and have to answer tough questions with no "right" answer such as rating idea quality (Christian/Dillman, 2004). Thus, an appropriate design of the rating scale can facilitate the process of mapping the response onto a given scale. In this context, evaluating the quality of customer-generated new product ideas could be oversimplified with a binary scale. A more complex scale, like a 5-star rating scale, may better support the process of integrating the different aspects of the idea into a single judgement and mapping this on different categories of the rating scale. Moreover, rating scales that embody cues such as definitions that explain the meaning of uncommon words may help the respondents to better express their ratings (Christian/Dillman/Smyth, 2007; Conrad et al., 2006) as the task can be better understood and subsequently more relevant information can be retrieved for the judgement. Thus, it is likely that a rating scale that breaks down the complex construct idea quality in different sub-scales addressing the different aspects of idea quality together will yield a higher rating accuracy than single item rating scales.

Consequently, we chose to implement three different rating means: 1. a binary "thumbs-up/thumbs-down" rating, 2. a more granular 5-star rating, and 3. a complex rating scale assessing important idea quality aspects "novelty," "value," "feasibility," and "elaboration" individually on a 5-point scale (Section 7.3.2). Subsequently, we evaluated the three rating scales in a large-scale experiment regarding their rating accuracy, user's rating satisfaction, user's attitude towards the website, and overall usability in order to arrive at a well-grounded design decision how effective rating mechanisms in online innovation communities should be designed.

7.3.2 Related Work

In order to conduct this experiment and analyse the resulting data, it is necessary to establish an understanding how the quality of an idea can be measured. Since all innovation begins with creative ideas (Chapter 4; Kristensson/Gustafsson/Archer, 2004), the evaluation of new service ideas is strongly related to the assessment of their inherent creativity.

On a general level, creative solutions are characterised as being new and useful (Amabile, 1996; Mayer, 1999; Niu/Sternberg, 2001; Plucker/Beghetto/Dow, 2004). Novelty is often defined as something being unique or rare. In this context, new ideas have not been expressed before (MacCrimmon/Wagner, 1994). A closely related trait of novelty is originality. Original ideas are not only new, but also surprising, imaginative, uncommon, or unexpected (Ang/Low, 2000; Dean et al., 2006), and many researchers see originality as the most important facet of creativity (Besemer/O'Quin, 1999; Runco/Pritzker, 1999). Another attribute of novelty is the paradigm relatedness (Besemer/O'Quin, 1986; Finke/Ward/Smith, 1996). This refers to an idea's transformational character, and describes the degree to which an idea helps to overcome established structures, i.e., how radical or revolutionary it is (Besemer/O'Quin, 1986). From a new product or service development perspective, an idea's paradigm relatedness refers to its innovativeness.

However, an idea's novelty is not sufficient for being unique and useful. Usefulness is the extent to which the idea responds to or solves a problem that is tangible and vital (Amabile, 1996; Dean et al., 2006). This dimension is also called an idea's value or relevance (Dean et al., 2006; Kristensson/Gustafsson/Archer, 2004; MacCrimmon/Wagner, 1994). In the scope of new product or service development, this refers frequently to an idea's financial potential (Cady/Valentine, 1999; Lilien et al., 2002; Rochford, 1991) and the strategic importance in terms of enabling competitive advantages (Cady/Valentine, 1999; Lilien et al., 2002; Rochford, 1991). From the innovator's perspective, an idea's feasibility is another vital dimension of idea quality. This dimension captures the ease with which an idea can be transformed into a commercial product and the fit between the idea and the absorbing organisation (Cady/Valentine, 1999; Lilien et al., 2002; Rochford, 1991). In this context, the fit is two-pronged: from an internal perspective, it refers to the absorbing organisation's strategy, capabilities, and resources and from an external perspective, to the fit between the idea and the absorbing organisation's image. Another trait of a high quality idea is its elaboration, which can be seen as the extent that it is complete, detailed, and clearly understandable (Dean et al., 2006).

In summary, creativity and idea quality are both complex constructs that have been a subject for creativity, group support system, and innovation researchers for years (Reinig/Briggs/Nunamaker, 2007). Researchers have suggested a variety of criteria for judging the quality of individual ideas, including

- novelty (e.g., MacCrimmon/Wagner, 1994),
- originality (e.g., Besemer/O'Quin, 1999; Runco/Pritzker, 1999; Ang/Low, 2000; Dean et al., 2006),
- feasibility (e.g., Diehl/Stroebe, 1991; Cady/Valentine, 1999; Lilien et al., 2002; Rochford, 1991),

- usefulness (e.g., Amabile, 1996; Dean et al., 2006),
- value or relevance (e.g., MacCrimmon/Wagner, 1994; Lilien et al., 2002; Kristensson/Gustafsson/Archer, 2004; Dean et al., 2006; Rochford, 1991), or
- effectiveness (e.g., Dean et al., 2006).

In the specific context of customer-generated new service ideas Blohm et al. and Riedl et al. suggest to measure idea quality using four distinct dimensions: novelty, feasibility, strategic relevance, and elaboration (Blohm et al., 2011a; Blohm et al., 2011b; Riedl et al., 2010a).

7.3.3 System Design

Several minor additions to the prototype were necessary in order to conduct the experiment. Through the multi-tenant architecture, setting-up several similar systems with individual configuration was already possible. However, several additional configuration options and functions were necessary.

Random Order The order of ideas on the platform has been randomised for each user so that all participants evaluated the ideas in a different order and a position bias can be avoided (Malhotra, 2009). In this regard the `userID` served as the random seed. Thus, the order of ideas displayed was randomised for each user. To activate this function we introduced a new boolean configuration variable (`randomOrder`).

Rating Visibility In order to avoid information cascades (Easley/Kleinberg, 2010), and group decision bias (Malone/Crowston, 1994) and thus a rating bias deriving from other participants' ratings, rating information of other participants had to be hidden. For that purpose we introduced a new boolean configuration variable (`communityRatingVisible`). When the function is activated, instead of the aggregated community rating of an idea, only the individual user's rating is displayed. If the user has not rated an idea an empty or blank rating is displayed which gives a clear visual impression that the idea has not yet been rated.

Rating Scales The three different rating scales were implemented using the rating concepts of the Idea Ontology introduced in Section 6.4.2. Through the use of the Idea Ontology a flexible system to handle different rating mechanisms was already in place. Using the `r:RatingKind` class the different rating aspects are realised: 1. overall (used by the promote/demote and 5-star rating), 2. novelty, 3. value, 4. feasibility, and 5. elaboration. The different rating mechanisms can be configured using an additional configuration variable (`rating`).

The additional configuration variables can be configured using the System Admin Portlet (Section 7.2.4.3). Table 7.17 summarises the additional system configuration introduced in component three.

Parameter	*Possible Value*	*Description*
`communityRating-Visible`	true | false	true: the aggregated community rating of an idea is visible false: only the individual user's rating is visible
`randomOrder`	true | false	Ideas are displayed in normal or randomised order.
`rating`	PromoteDemote | 5star | complex	Configures the rating mechanism.
`ratingAspects`	[aspect1:aspect2:...]	The individual rating aspects of the complex rating are specified as a colon-separated list.
`ratingAspectsUI`	[label1:label2:...]	The labels of the complex rating aspects are configured.

Table 7.17: *Summary of additional configuration options added in component three.*

7.3.4 System Implementation

We implemented a new user interface for each of the three rating mechanisms which can be configured using the additional configuration variables introduced in the previous section. The promote/demote and 5-star rating are directly accessible on the homepage showing ideas in list mode. Due to space constraints, the complex rating which consists of multiple items is only accessible on the detail page of an idea. Using the multi-tenant architecture, we set-up three identical system under three distinct URLs: `http://exp1.ideaontology.org/`, `http://exp2.ideaontology.org/`, and `http://exp3.ideaontology.org/`. Figures 7.38, 7.39, and 7.40 show screenshots of the resulting three systems.

7.3.5 Experiment Set-Up

Extending previous decision management research, the experiment focuses on analysing effective idea rating and selection mechanisms in online innovation communities. The experiment seeks to advance knowledge about the effective and efficient utilisation of information technology to improve online innovation portals. To gain insights into how different rating mechanisms work we conducted a multi-method study. Using a pool of 24 real-world ideas submitted in a public idea competition (Blohm et al., 2011a; Blohm et al., 2011b) our study comprised a Web-based experiment, a survey measuring rating satisfaction, attitude, and usability, as well as an independent expert rating of idea quality. Through triangulation, we seek to gain a more comprehensive insight into how community rating mechanisms work. Using the experimental design for comparing rating scales we aim to design an effective idea rating mechanism for the TEXO Innovation Repository and simultaneously advance knowledge about the use of online innovation communities.

In general, controlled experiments are considered the backbone of system evaluation (Plaisant, 2004). Furthermore, scholars recommend useing realistic scenarios to perform usability evaluation. As this experiment uses a realistic rating scenario involving 24 real-world ideas the experiment also serves as an important step of usability testing of the overall innovation portal.

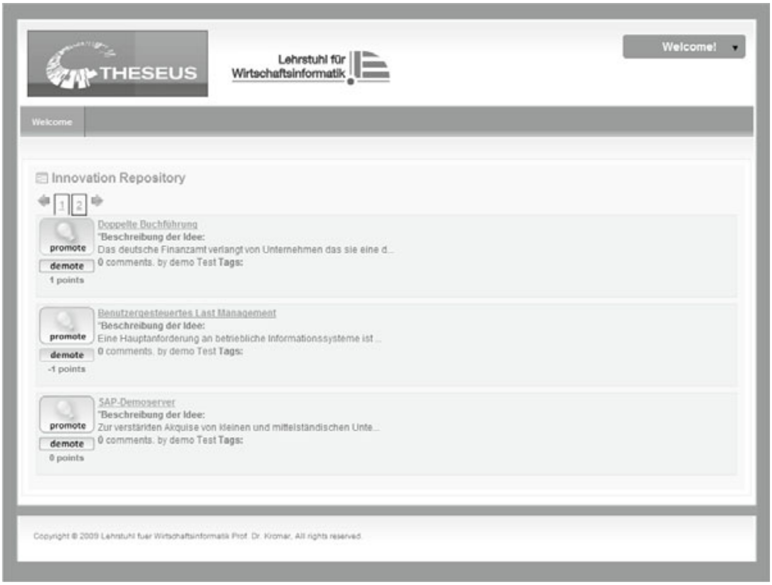


Figure 7.38: *Promote/demote rating scale.*

Figure 7.39: *5-star rating scale.*

Figure 7.40: *Complex rating scale on the details page of an idea: four 5-point scales for (1) novelty, (2) value, (3) feasibility, and (4) elaboration ranging from "low" to "high."*

7.3.5.1 Participants

Participants of topic related open innovation platforms and virtual communities can be seen as the target population of our experiment and open innovation communities in general. Prior research has shown that people engaged in user innovation and virtual communities for innovation are predominantly male, young and well educated (Franke/Shah, 2003; Jeppesen/Frederiksen, 2006; Jokisch, 2007; Kristensson/Gustafsson/Archer, 2004; Schulz/Wagner, 2008; Walcher, 2007). 349 participants took part in the experiment of those 313 were included into the analysis. 36 participants had to be excluded because they failed to complete both the rating task and the questionnaire. Our sample population consisted of undergraduate and graduate students from four information systems courses, two of them directly related to SAP education, as well as research assistants from the same area at a large German university. Students from three of the courses were offered homework credit points for participating in the experiment.

We considered students of the selected SAP related educational courses and information system experts to be appropriate subjects for this study because the experimental task requires knowledge of SAP software systems to judge idea quality related to SAP software. Furthermore, it can be argued that IS/SAP course students are suitable experiment participants as they represent actual users of innovation platforms. On a general level, Voich (1995) found the values and beliefs of students to be representative of individuals in a variety of occupations. Table 7.18 summarises the demographic profile of the study participants.

N	313
Mean Age	22.81 years
Gender	Male: 67.7 % Female: 32.3 %
Highest University Degree	None: 69.3 % Bachelor: 25.2 % Master: 5.4 %

Table 7.18: *Participant demographics.*

7.3.5.2 Idea Sample

The ideas evaluated in this experiment were taken from an idea competition that was conducted in summer 2008 with a running time of 14 weeks. A detailed description of the idea competition, the submitted ideas, and the expert rating can be found in Blohm et al. (2011a) and Blohm et al. (2011b). In this idea competition SAP users were asked to submit ideas that improve the SAP software or that bring out radical innovations in the scope of the SAP software. In total 58 new product ideas were contributed by 39 different users.

Among these ideas, idea quality is normally distributed (Blohm et al., 2011a; Blohm et al., 2011b). The ideas varied in length, i.e., elaboration, between half and a full A4 page. Conducting an experiment with all ideas implied a substantial workload for all participants. Hence, a stratified sample of 24 ideas was drawn in order to limit participation workload. This sample comprised 8 ideas with high, medium, and low quality respectively, based on the independent expert ranking. The sample size was considered sufficient as 20 to 30 ideas are generally used to measure the variance of creativity ratings in creativity research (Caroff/Besancon, 2008; Runco/Smith, 1992; Runco/Basadur, 1993).

7.3.5.3 Experimental Task and Design

The experiment has been performed as a Web-based experiment using the innovation portal described in component one (Section 7.1). Standard features of the platform like idea submissions, commenting, searching, and sorting have been disabled and only the rating mechanisms were activated (see screenshots in Section 7.3.4). The customisation of the system was facilitated by the additional configuration functionality implemented for this experiment (Section 7.3.4). The ideas to be evaluated comprised of a title and a description. Participants performed the task on their own computers (at home, at work, in a computer lab) via a Web browser. Before starting the experiment we tested whether all common browsers displayed the innovation portal in a similar way and no irregularities were discovered. As a Web experiment closely reflects the actual usage scenarios of virtual communities for innovation and open innovation platforms, a high external validity of our results can be assured. Participants can rate the ideas in their natural environment and can allocate as much time to completing the rating task as they want to. Furthermore, the internal validity of results is assessed by analysing the log files on the idea platform. Doing so, user responses that have an improbable behaviour such as responding too fast can be identified and excluded from analysis. The time stamp of each performed rating has been recorded so as to identify users who just clicked through the rating in order to exclude them from the sample. Every idea is rated individually by one of three scales (see below).

The system provides immediate visual feedback to a successful rating (i.e., the respective rating button/star is highlighted). Users are also able to update their ratings, again with immediate visual feedback. Through the update mechanism it is assured that every user can rate every idea only once. In order to avoid information cascades and group decision bias rating information of other participants is not visible (`communityRatingVisible=false`). Ideas that have not been rated are clearly visible due to the coloured highlighting that is shown once an idea has been rated. This made it convenient for users to navigate through the system to identify ideas that have not yet been rated or to check for completeness.

Participants were asked to rate the ideas with the following task description:

> Please carefully read through all ideas and provide a rating of the idea quality as judged by your personal experience. Please consider an idea's overall quality in terms of its novelty, relevance, feasibility and elaborateness for your rating as indicated by the idea's title and description.

7.3.5.4 Rating Scales

For our experiment three different configurations of the innovation portal have been set up, one for each of the rating scales, using the multi-tenant architecture explained in Section 7.2.5.1 and the additional rating functionality explained in Section 7.3.4. Each system was accessible under a different URL. The scales comprise of a binary rating scale (*promote/demote rating*), a five-point rating scale (*5-star rating*) and a complex rating scale. Whereas the promote/demote as well as the 5-star rating reflect an aggregated measure for idea quality, the *complex rating* scales consisted of four 5-point rating scales reflecting the single dimensions of idea quality used in the expert rating (Table 7.19). The 5-point rating scale of the complex rating ranged from "low", through "medium" to "high" (cf. Figure 7.40).

Rating Attribute	*Label with Rating Instruction*
Novelty	How novel do you think this idea is?
Value	What do you think is the value of this idea if implemented?
Feasibility	How easy is it to implement this idea?
Elaboration	Is the idea well elaborated?

Table 7.19: *Rating aspects of the complex rating.*

7.3.5.5 Procedure

Participants of the sample population were first randomly assigned to one of the three ratings scale treatments (random sampling without replacement). Based on the random assignment, we invited the participants via a personalised e-mail including a link with the respective system URL and the online questionnaire. Participants completed the rating task distributed over the experiment duration of four weeks in November and December 2009. After the four weeks the online systems were closed and the data sample was exported for the data analysis. Table 7.20 summarises the participants for each of the three rating scale treatments.

	Promote/Demote	*5-Star*	*Complex Rating*
N	94	103	116

Table 7.20: *Number of participants of the different rating scale treatments.*

7.3.5.6 Multi-Method Approach

In this evaluation experiment, three research and analysis methodologies are employed (Web experiment, quantitative survey analysis, expert rating) to investigate the influence of the rating scale on rating accuracy, user satisfaction, and attitude. Various researchers advocate the use of multiple methods of data collection, both to gain a deeper insight and more reliable results (Boudreau/Gefen/Straub, 2001; Palvia et al., 2004; Sharma/ Yetton/Crawford, 2009). Similar to an approach taken by Cyr et al. (2009) we aim for greater robustness in the current investigation through the use of multiple methods. The following sections explain each of the three methods of data collection.

Experiment Rating Initially, 349 participants took part in the experiment. Idea raters that did not rate all ideas, did not fill out the survey completely, or rated the ideas in less than 5 minutes were discarded form the analysis. Through the random sampling an equal amount of users have been invited for each treatment group. The significant difference in valid participants can be explained through unequal distribution of drop-outs through incomplete ratings and questionnaire responses. The remaining 313 idea raters performed 15864 ratings in total. The median time it took the users to rate the 24 ideas (measured by the difference between the timestamp of the first and the last rating that a given user submitted) was 35 minutes and 35 seconds. It has to be noted, however, that the time taken for submitting the ratings does not include the time a user spent on reading through the ideas before submitting the first rating (i.e., a user might spend a considerable amount of time reading through all ideas before starting to submit ratings). Table 7.21 summarises the total ratings for each of the 24 ideas. The following numeric values are used to represent the ratings:

Promote/Demote scale: a positive rating is represented as 1, a negative rating as -1.
5-Star scale: values 1-5 are used to represent the number of stars given.
Complex scale: each rating aspect is represented using the values 1-5; the final complex rating is the arithmetic mean of the four aspects.

	Promote/Demote			*5-Star*			*Complex*		
Idea	*N*	*Mean*	*SD*	*N*	*Mean*	*SD*	*N*	*Mean*	*SD*
SAP Demo Server	94	0.46	0.89	103	3.46	1.13	116	3.38	1.04
Virtual Community	94	0.38	0.93	103	3.27	1.09	116	3.36	1.14
SAP Workbench	94	0.21	0.98	103	3.27	0.91	116	3.33	1.04
Print Menu	94	0.75	0.66	103	3.91	1.10	116	3.26	1.24
Last Management	94	0.19	0.98	103	3.20	0.94	116	3.26	1.12
Small Business Portal	94	0.35	0.94	103	3.42	1.05	116	3.25	1.00
Delegator	94	0.31	0.95	103	3.20	1.10	116	3.22	1.04
Idea Visualisation	94	0.10	0.99	103	3.23	1.17	116	3.22	1.11
SAP Snagit	94	0.25	0.97	103	3.19	1.38	116	3.22	1.17
Public Administration	94	0.52	0.85	103	3.63	1.21	116	3.21	1.17
SAP at Schools	94	0.23	0.97	103	3.29	1.38	116	3.21	1.13
Tour Planning	94	0.50	0.87	103	3.45	1.21	116	3.19	1.07
SME	94	0.38	0.93	103	3.42	1.18	116	3.15	1.15
Data Integration	94	0.35	0.94	103	3.41	1.10	116	3.14	1.06
Reengineering Tool	94	0.08	1.00	103	3.22	1.06	116	3.12	1.02
E-Recruiting	94	0.17	0.99	103	3.23	1.08	116	3.12	1.07
Mouse Gestures	94	-0.06	1.00	103	2.88	1.31	116	3.06	1.12
Standard Buttons	94	0.52	0.85	103	3.82	1.14	116	3.02	1.26
Double Bookkeeping	94	0.50	0.87	103	3.65	1.38	116	2.95	1.35
CAD CO	94	0.25	0.97	103	3.32	1.27	116	2.86	1.24
Dynamic Search	94	0.35	0.94	103	3.18	1.23	116	2.86	1.21
Service Desk	94	-0.04	1.00	103	2.82	1.10	116	2.77	0.99
Simplified Login	94	-0.21	0.98	103	2.71	1.34	116	2.68	1.22
Warm Welcome	94	-0.63	0.78	103	1.83	1.22	116	2.56	1.58

Table 7.21: *Summarised rating results. Promote/demote rating uses -1 to +1 scaling, 5-star and complex rating use 1-5 scaling. Sorted by complex mean (idea titles shortened and translated by the authors).*

Questionnaire After the experiment, rating satisfaction, user attitude, and usability measures were collected through an online survey among the participants as previous research suggested that these measures are most important (Galletta et al., 1995). In survey research, a key validation criterion is content validity. Content validity considers how representative and comprehensive the items are in creating the experimental constructs. To ensure content validity we adapted measurement scales that have already been used in the context of information system acceptance, open innovation, and computer-human interaction studies before. Therefore, content validity for the three constructs was established through past research (Straub, 1989).

Satisfaction with rating scales is usually not measured as a quality criterion of rating scales (Ganassali, 2008). Thus, we adapted our scale for measuring rating satisfaction based on scales for measuring satisfaction with websites (Oliver/Swan, 1989; Shankar/Smith/Rangaswamy, 2003) and website usability as it strongly determines satisfaction in human computer-interaction (Lindgaard/Dudek, 2003; Shankar/Smith/Rangaswamy, 2003). All satisfaction items were measured with a 5-point Likert scale.

Much of the research in the HCI literature frequently excludes affective variables such as attitudes from system evaluation. Attitude measures have been used as surrogates for success at different levels of granularity (Galletta et al., 2004). The word “attitude” can cover a variety of feelings, such as general satisfaction, perceptions of quality, and emotional response. Therefore, as stated by Au/Ngai/Cheng (2002), we assume that “satisfaction comprises an affective attitude towards an object;” in this case the rating experiment website. We measured attitudes using questions adapted from Galletta et al. (2004) and Geissler/Zinkhan/Wastson (2006), which were tested for reliability and validity in previous research (MacKenzie/Lutz/Belch, 1986; Chin/Diehl/Norman, 1988). All attitude items where measured on a 5-point semantic differential scale.

Usability is a key attribute of information systems (Nielsen, 1994). To analyse user's interaction with the system we measured usability using validated and tested standard items from Venkatesh et al. (2003), Davis (1989), Davis/Bagozzi/Warshaw (1989), and the well accepted IBM *Computer System Usability Questionnaire* (Lewis, 1993). All usability items were measured on a 5-point Likert scale.

The entire survey was pretested with a small sample of ten participants, reflecting the different groups of participants. They were asked to provide detailed comments on the survey such as working or concept confusion. Based on this feedback we made minor changes to the survey. Appendix B shows a summary of the survey items.

Expert Rating For assessing the validity of the different rating scales the participants idea quality ratings are compared with an independent expert rating. The ideas from the idea contest were evaluated by a qualified expert jury using the consensual assessment technique (Amabile, 1996). This assessment technique is based on creativity research and was already used several times for assessing the quality of customer generated ideas (Blohm et al., 2011a; Franke/von Hippel/Schreier, 2006; Kristensson/Gustafsson/Archer, 2004; Matthing et al., 2006; Piller/Walcher, 2006; Walcher, 2007). Using this method ideas are evaluated by a jury consisting of experts in the given domain. In our case the jury consisted of 7 referees, which were either university professors, employees of the initiator SAP, or the German SAP University Competence Centres. The complex construct of idea quality was operationalised in four dimensions and measured in 15 items. For evaluation the idea descriptions were copied into separate evaluation forms which contained the scales for idea evaluation as well. The evaluation forms were handed out to the referees in a randomised order. All judges were assigned to rate the ideas with the 15 different items on a rating scale from 1 (lowest) to 7 (highest). Each member of the jury evaluated the ideas independent from the others. In order to assess idea quality validly and reliably we conducted exploratory and confirmatory factor analysis. A detailed description of this procedure can be found in (Blohm et al., 2011a).

7.3.6 Artefact Evaluation

We performed a correlation and reliability analysis of the rating satisfaction, user attitude, and usability scales using PASW Statistics 18.0 (former SPSS). Construct validity assesses the degree to which a construct measures the variable of interest and whether “the measures chosen 'fit' together in such a way as to capture the essence of the con-

	Mean	*SD*	*Rating Satisfaction*	*User Attitude*	*Usability*
Rating Satisfaction (4 items)	3.36	0.72	(0.67)		
User Attitude (7 items)	3.03	0.57	0.55**	(0.83)	
Usability (5 items)	4.14	0.68	0.35**	0.12*	(0.80)

Table 7.22: *Correlations of rating satisfaction, user attitude, and usability; Cronbach's Alpha are reported in parentheses on the diagonal ($N = 313$, ** significant at the 0.01 level (2-tailed), * significant at the 0.05 level (2-tailed)).*

struct" (Straub/Boudreau/Gefen, 2004, 388). There should be high correlations between items of the same construct (convergent validity), and low correlations between items of different constructs (discriminant validity) (Straub, 1989). One method to establish construct validity, specifically convergent and discriminant validity, is to use a weighted, summed composite score for the "latent" construct (Bagozzi/Fornell, 1982). These composites scores can be compared against a normalised score for each measure to be certain that items relate more strongly to their own latent construct than to other constructs. The correlations for the summed composite score using equal weights for all items are shown in Table 7.22. As all items were measured on 5-point scales, no normalisation was necessary. All correlations are statistically significant and show no, or only slight cross loading.

While construct validity is a measurement between constructs, reliability is a measurement within a construct (Straub/Boudreau/Gefen, 2004). A generally recognised technique was used to assess reliability (Boudreau/Gefen/Straub, 2001): internal consistency. We tested estimates of internal consistency of the scales using Cronbach's Alpha (Cronbach, 1951). Alpha should be higher than 0.70 to indicate an acceptable value for internal consistency (Malhotra, 2009; Nunnally, 1978). Ideal estimate of internal consistency should be $0.80 \leq \alpha \leq 0.90$ (Clark/Watson, 1995; DeVellis, 2003). Alphas of 0.60 are also commonly accepted, in particular in exploratory research (Robinson/Shaver/Wrightsman, 1991; Hair et al., 2006). Cronbach's Alpha are reported in parentheses on the diagonal of Table 7.22. User attitude and usability show optimal internal consistency while rating satisfaction is only marginally reliable but above the acceptable threshold of 0.65 (DeVellis, 2003). Overall, the good reliabilities of the scales based on Cronbach's Alpha can be confirmed. The following sections present the detail data analysis.

In summary, our instrument provided satisfactory content validity (established through past research); satisfactory construct validity (as evidenced from high correlations between items of the same construct and acceptable correlations between items of different constructs); and satisfactory construct reliability (as evidenced from acceptable internal consistency).

7.3.6.1 Rating Accuracy

Participants' evaluations are considered to be of high accuracy if the participants are able to effectively identify the "best" ideas among all ideas. In the context of product or service ideas, the best ideas would be those creating the highest profits after having been implemented by a company. This true idea quality is a priori unknown and the community ratings can only serve as a pre-selection for the following internal review phase (Di Gangi/ Wasko, 2009). Thus, the particular quality score of a given idea that has been assigned by the community is in principle not relevant. It is more important that the best ideas are identified correctly by the participants (Reinig/Briggs/Nunamaker, 2007; Girotra/ Terwiesch/Ulrich, 2010). In creativity research judgemental accuracy of laypersons is often determined by assessing the concurrent validity of their judgements with those of an expert jury, e.g., by counting “good ideas” or “bad ideas” that have been identified correctly by the non-experts (Runco/Smith, 1992; Runco/Basadur, 1993). We consider a promote/demote rating correct if a good idea has been rated with “promote” and a bad idea with “demote.” On the 5-star scale, we consider 5 and 4 stars correct for good ideas and 1 or 2 stars correct for bad ideas. On the complex scale which consists of four ratings of 1 to 5 points, we consider a mean equal to or above 4.0 as correct and a mean lower or equal to 2.0 as correct.

Current research about customer-generated new product or service ideas shows that about 10-30% of these ideas can be regarded as high quality ideas (Blohm et al., 2011a; Blohm et al., 2011b; Franke/von Hippel/Schreier, 2006; Walcher, 2007). Thus, we defined two cut-off criteria with 5 ideas (ca. 21%) and 8 ideas (ca. 33%) from the high quality sample strata as “top ideas.” Respectively, the 5 and 8 ideas from the low quality sample strata were classified as “bad ideas.” We performed all of the following analyses with both cut-off criteria leading to almost identical results. Hence, we report only the results of the more severe 5 idea cut-off-ratio as this better reflects reality.

In the first instance, we tested the accuracy of our rating scales by counting the correctly classified high and low quality ideas of each user (Figure 7.41). Results were analysed using a one-way analysis of variance (ANOVA), between-subject design. Analysis of variance revealed that the binary promote/demote rating yielded the significantly highest amount of correctly classified ideas ($F_{2,310} = 69{,}78$, $p < 0.001$). Bonferroni post-hoc comparisons revealed that differences between all rating types are significant ($p < 0.001$). However, simultaneously the promote/demote rating leads to significant higher misclassification of ideas compared to the 5-star and the complex rating, so that good ideas are wrongly classified as bad ones and vice versa ($F_{2,310} = 225.14$, $p < 0.001$) (Figure 7.42). The rating error is significantly different between all rating types ($p < 0.001$). To arrive at an overall measure, we operationalised rating accuracy with an adjusted fit-score. This fit-score was calculated by subtracting the wrongly classified ideas (error) from the correctly classified ideas (correct) (Figure 7.43). Here, the complex rating scale produced the significantly highest rating accuracy, followed by the 5-star and the promote/demote scale. Significant main effects for the influence of the rating scale on rating accuracy ($F_{2,310} = 9{,}05$, $p < 0.001$) could be found.

Finally, we checked whether there is a statistically significant concurrence between the ratings collected through the website and the expert evaluation. Therefore, the individual user ratings were aggregated and a quality ranking of the ideas was constructed according to the mean quality scores of the ideas. Then, correlation analysis was applied (Table 7.23). In comparison to the expert rating the complex rating scale shows the highest concurrence with $r = 0.62$ ($p < 0.01$). Neither the promote/demote nor the 5-star rating correlate with the expert rating ($r = 0.04$ and $r = 0.08$). However, all rating scales show strong, very significant correlations among each other. In particular, the aggregated idea rankings of the promote/demote scale and the 5-star scale are nearly identical ($r = 0.97$, $p < 0.001$).

7.3.6.2 Rating Satisfaction

Analysing user's satisfaction with their rating, the 5-star rating leads to the significantly highest degree of user satisfaction followed by the complex and the promote/demote scale (Figure 7.44). We found significant differences between the three rating scales ($p < 0.05$). Means of rating satisfaction range between 3.20 and 3.47 which indicate user's general satisfaction with the idea ratings.

7.3.6.3 User Attitude Towards Website

We then analysed user's attitude towards the website. Across the three rating scales, user attitude is almost identical (means 2.93, 3.04, and 3.11) with no significant difference between the scales. Rating attitude is shown in Figure 7.45. Considering the mean values, users seem to have a neutral attitude towards the platform. Overall, the attitude towards the website is not influenced by the rating mechanisms. Consequently, it can be assumed that the rating mechanism is perceived as an independent component of the overall system which does not influence other aspects of the system design.

7.3.6.4 Usability

The 5-star rating scale achieved the highest usability evaluation (mean 4.17) followed by the complex rating and the promote/demote rating (means 4.12 and 4.14). We found no significant difference between the three groups which confirms that all three rating scales are well implemented and offer a similar user experience. Figure 7.46 shows a histogram of the 5 usability items (5-point Likert scale, 1 = strongly disagree to 5 = strongly agree). The analysis reveals a good usability of the website. For example, 62% of the users strongly agree with the statements that the system is easy to use and easy to learn. Clearly the website was perceived as positive and easy to use resulting in good usability measures. As participants performed the experiment on their own computers the experiment simultaneously evaluated the prototype on a variety of hardware and software systems, including different browsers. Due to the generally good usability evaluation without systematic outliers, it can be assumed that the prototype worked well on these different systems and browsers.

7.3.6.5 Summary of Evaluation

Using a multi-method approach including a controlled experiment, a questionnaire, and an independent expert evaluation of idea quality, we analysed the relationships between

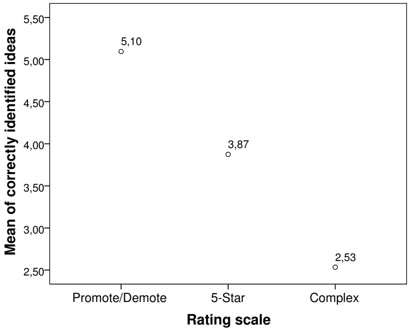


Figure 7.41: *Correct identification of top ideas as good and bottom ideas as bad (mean number of correctly identified ideas).*

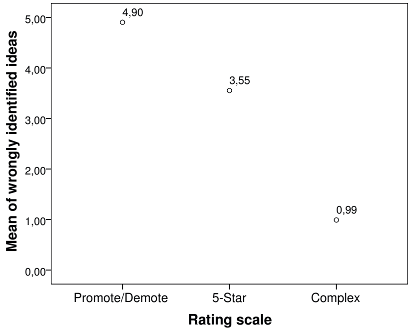


Figure 7.42: *Error identifying top ideas as good and bottom ideas as bad (mean number of errors).*

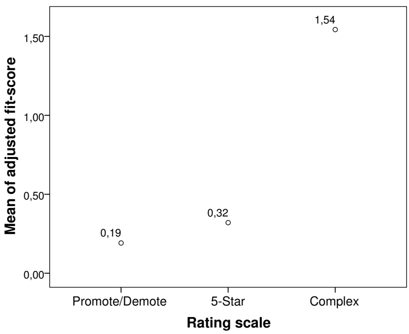


Figure 7.43: *Overall rating accuracy (mean correctly identified ideas minus error).*

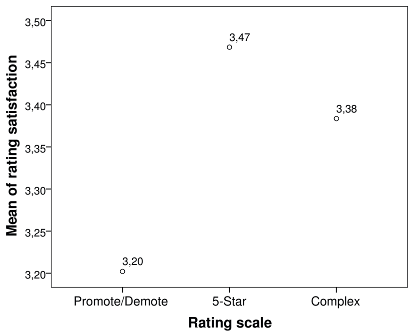


Figure 7.44: *Rating satisfaction (1 = strongly disagree; 5 = strongly agree).*

	Expert Rating	*Promote/Demote Rating*	*5-Star Rating*
Promote/Demote Rating	0.04		
5-Star Rating	0.08	0.97***	
Complex Rating	0.62**	0.70***	0.68***

Table 7.23: *Correlations of expert rating and rating scales (N = 24, *** significant with $p < 0.001$, ** significant with $p < 0.01$).*

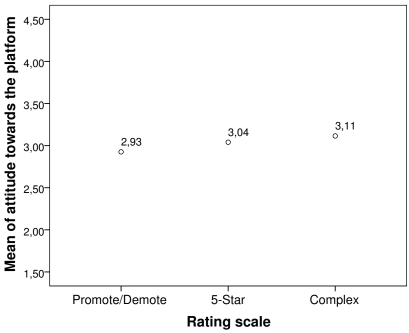


Figure 7.45: *User attitude towards the website (1 = strongly disagree; 5 = strongly agree).*

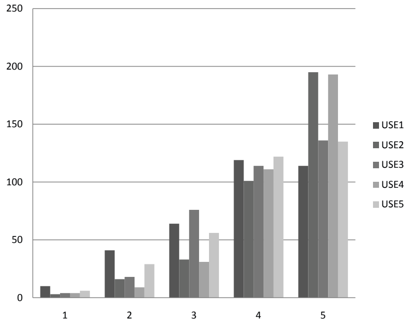


Figure 7.46: *Usability evaluation histogram of usability measures USE1-USE5 (cf. Appendix B; 1 = strongly disagree; 5 = strongly agree).*

three different rating scales and the resulting judgement accuracy, rating satisfaction, and user attitude.

Regarding the main condition of interest, rating accuracy, we reveal that the complex rating scale leads to a significantly higher rating accuracy than the promote/demote rating and the 5-star rating ($p < 0.001$). Our results indicate that the highly popular promote/demote rating that is frequently used in innovation communities (cf. Table 6.2) has severe limitations. While it works well to identify top ideas as good and bottom ideas as bad it also produces the highest error (classifying top ideas as bad and bottom ideas as good). This results from a user bias of either rating very positively (positivity bias, Tourangeau/Rips/Rasinski, 2000) or very negatively (e.g., for the 24 ideas a user would submit 20 promotes and only 4 demotes or vice versa). Thus, overall, the aggregated promote/demote rating is without insights and results in a near-random idea rating. This suggests the conclusion that this quick and easy decision making process fails. This can be explained in light of a cognitive response process (Tourangeau/Rips/Rasinski, 2000): while the rating scale has only little influence on the comprehension, information retrieval, and judgement phase, it has major influence on the reporting and response selection. Respondents failed to map their judgement on the two scale-endpoints of the binary rating scale. More granular rating scales offer more discretion for this mapping process which leads to higher rating accuracy.

Another possible explanation could be that the different ratings scales do address different constructs associated with idea quality. The complex rating scale may represent a judgement of idea quality and the less granular scales an indication of idea popularity. However, idea quality and idea popularity do not necessarily have to be the same construct. Thus, they could activate different cognitive evaluation patterns in the decision process which lead to different results.

The judgement of rating accuracy, however, has to be seen in light of an optimal degree of granularity. The promote/demote rating scores significantly lower regarding user satisfaction than the 5-star and the complex rating scale ($p < 0.01$) while the data shows no significant difference between the 5-star and complex rating scale. A possible explanation for this phenomenon is that a more complex scale allows users to express their individual rating judgement more accurately which increases their rating satisfaction. According to Janis' and Mann's (1977; 1982) conflict theory of decision making, the binary rating seems to elicit a major rating conflict resulting in high stress which cannot be resolved leading to low decision satisfaction and regret. More granular rating scales do expose idea raters to a more acceptable level of stress. However, a too granular rating scale reverses this effect as the accompanying rating effort rises. Thus, the 5-star rating seems to have an optimal degree of granularity in terms of rating satisfaction. Based on this multi-method analysis of the three rating mechanisms the following design guidelines for component three can be expressed:

Implications for the System Design The complex rating scale should be used as it clearly provides the highest rating accuracy. If user satisfaction and drop-out rates are an issue the 5-star rating scale provides a good compromise and can be used to achieve a tradeoff between rating accuracy and rating satisfaction.

Our experiment confirms the "wisdom of the crowds" theory that a larger group of people can perform decision tasks as good as experts irrespective of the knowledge of the individual (Surowiecki, 2005; Leimeister, 2010; Malone/Laubacher/Dellarocas, 2010). However, a key problem of the "wisdom of crowds" is the inability to distinguish between the actual wisdom and "the mob that rules." The foundation of this problem lies in the improper usage of methods to delegate decision tasks to an anonymous group (Roman, 2009). Our experiment shows that in a well designed setting with well designed IT support, a "crowd" can indeed perform similar to experts. The effective design of those rating mechanisms enhances the validity and reliability of resulting idea ratings and supports the selection of the best ideas for further refinement or implementation in a company's innovation process.

Analysis of user's attitude towards the platform shows no significant difference between the three rating mechanisms. This supports the assumption that the rating mechanism is perceived as an independent component of the overall system. This, in turn, supports the theory-driven design approach organised in consecutive design phases. There is no evidence that the rating mechanism causes additional unintended side-effects which need to be considered in the following design phase. Regarding the usability evaluation, the website was perceived as positive and easy to use. Furthermore, as participants performed the experiment on their own computers a good usability across a variety of systems and browsers can be assumed. Overall, the system operated very stable and we collected 15864 ratings submitted by 313 user over a period of four weeks without system downtime. The system stability and the usability evaluation shows convincingly that the prototype is well implemented, reliable, and fit for use in large scale scenarios with many users.

In summary, a combination of a Web-based experiment, statistical analysis, and expert rating provides insights not possible with only one source of data and thus offers a fuller appreciation of the phenomena of online innovation communities. Overall, there is mutual support between the methodologies. The quantitative analysis of the "wisdom of crowds" phenomenon adds to our knowledge as to how a community can be used for tasks commonly performed by experts. This helps to alleviate the original problem setting of large idea sets including similar ideas collected from different systems that need to be evaluated in order to select the most promising ideas for further refinement or implementation.

7.3.7 Discussion

This section presented the detail design, implementation, and evaluation of component three, an idea rating mechanism for the innovation portal. As mentioned in the introduction, our research related to component three serves three goals.

Implementation of an Idea Rating Mechanism The multi-method evaluation of the idea rating mechanism demonstrates that a well designed rating mechanism enables an online innovation community to achieve similar results regarding idea evaluation and selection than a group of experts. Hence, the idea rating mechanism successfully implements an operational efficiency feature that supports a converging innovation phase by filtering ideas through idea rating. The evaluation demonstrates that the program (an idea rating mechanism implemented in an online innovation portal) is able to start the causal process (a converging, decision-oriented task structure), which then leads to the desired effect (a reduced number of ideas for refinement and implementation). Overall, component three adds crucial system functionality to the overall system design of the TEXO Innovation Repository and implements a tradeoff to the uncontrolled innovation process resulting from the previous design phase. However, as the idea rating mechanism targets operational efficiency this results in an unbalanced blend between support for operational and generative tasks. Consequently, requirement C7 is not yet satisfied.

Theoretical and Practical Implications From a theoretical perspective, we extend previous decision management research and offer insights into how different rating mechanisms for idea selection work within the context of online innovation communities. Contrary to the established practice of Internet-based rating which proposes that rating scales should be as simple as possible to avoid user drop-out, our research finds that very simple scales lead to near-random results. Consequently, more complex scales should be used, accepting higher drop-out rates but improving rating accuracy. Furthermore, our results demonstrate that in a well designed setting, a collective evaluation can match the performance of experts on a given evaluation task. Despite the widespread use of rating mechanisms in online innovation communities these popular tools have not yet been analysed in depth. An inherent weakness to crowdsourcing is the inability to distinguish between the "wisdom of crowds" and "the mob that rules." Our multi-method research is the first to offer reliable results comparing collective decision making with independent expert ratings, helping us to shed light on the question of how to use crowds and for which tasks within complex decision making processes. Our research results in design guidelines favouring more complex rating mechanisms over simpler ones to improve, both decision quality, and user satisfaction.

From a practical perspective our research shows that the effective and accurate design of mechanisms for collective decision making is critical to harness the wisdom of the crowds. If the design is ill-fitted to the desired task, outcomes can be misleading or simply wrong. Our research suggests that operators of popular innovation communities should re-consider their choice of using thumbs-up, thumbs-down rating as it leads to, both near-random rating results, and low user satisfaction. To improve user satisfaction and reliability of collective decision making operators of online innovation communities should opt for multi-attribute scales such as the complex scale tested in this research. While these scales might result in a lower number of submitted ratings due to higher drop-out rates the same psychometric attributes as with the promote/demote rating can be achieved with less ratings (King/King/Klockars, 1983).

Usability Evaluation Through the experiment the prototype system was subjected to a comprehensive stress test. During a four week period we collected 15864 ratings submitted by 313 users without system downtime. Furthermore, users provided valuable feedback regarding the usability of the system. The website was perceived as positive, easy to use, and easy to learn. Overall, usability measured through a 5-item scale was judged very positive by the participants of the experiment. The usability evaluation shows convincingly that the prototype is well implemented, reliable, and fit for use in large scale scenarios.

Some general shortcomings resulting from conducting a controlled experiment apply to our research. Through this research design users had no choice which ideas to rate as all ideas had to be rated. This might lead to a distortion of results regarding the promote/demote rating as this scale does not offer a neutral rating. Furthermore, following the "wisdom of the crowd" paradigm, the expert rating might be deficient as experts are more prone to a fixed mind-set than a broader community and thus might have overlooked certain aspects of some ideas.

A possible design guideline and direction for future research can be given. An effective way of involving a community could be a combination of quality rating and popularity signalling. Instead of using promote/demote as a rating mechanism to judge idea quality, it should be used as a voting mechanism to signal popularity. To function as a signalling mechanism voting of other users should be visible. In a parallel approach, complex scales should be used to judge the actual idea quality. Here, ratings of other users should not be visible to avoid information cascades. To overcome issues with limited absorptive capacity by companies a combination of idea quality and idea popularity can then be used to decide which ideas to adopt based on popularity and actual idea quality.

7.4 Component Four: Guided User Interaction

After implementing an idea rating mechanism in component three the TEXO Innovation Repository offers an effective approach to evaluate and select ideas. This supports in particular the operational efficiency side of the overall system design (Section 5) which should result in better structured innovation processes. Despite this functionality, the overall system suffers from the sheer amount of unchannelled contributions. Furthermore, as ideas are submitted independently there is high redundancy as different users are likely to perceive similar needs. Kornish/Ulrich (2009) report that up to 32% of the ideas in an idea pool are redundant. However, for the idea rating mechanism to work effectively, a high quality idea pool is necessary. In summary, after the implementation of component three, the system suffers from duplicates and ideas of low quality and low maturity. To alleviate this problem and achieve a better blend of operational efficiency and generative capacity functionality (criterion C7), component four extends the innovation portal with the exemplary implementation of an generative capacity feature: a mechanism to guide user contributions in order to reduce the amount of duplicates in the system and improve idea elaboration. In this section, we present our research related to the implementation and evaluation of the guided user interaction.

In addition to realising the overall system design, our design, implementation, and evaluation of component four makes a contribution by itself. Based on theory-driven design, using contribution behaviour theory, we develop a non-intuitive system design that counters established knowledge regarding the use of clustering in idea generation. Our work goes beyond published research and aims to extend current knowledge regarding the design of IT systems to better support online innovation communities and thus to contribute to the body of knowledge. In summary, the research presented in this section serves three goals:

1. Implement a generative capacity feature for the overall TEXO Innovation Repository that allows channelling independent user contributions to avoid duplicates and raw ideas in the idea pool. Thus, component four helps to provide more complete tool support for innovation management in service ecosystems by adding crucial system functionality to the overall TEXO Innovation Repository.

2. Contribute to the scientific knowledge base regarding the design of innovation portals. While current innovation portals that support online innovation communities are based on common-sense designs, we present a theory-driven design that promises better results by introducing user guiding in the contribution process. From a theoretical perspective, we present a novel use of clustering in the idea generation process in the context of online innovation communities. From a practical perspective, our research provides actionable design guidelines for establishing awareness of previous contributions and thus channelling individual efforts in innovation portals.

3. Perform additional usability tests with the TEXO Innovation Repository in general, not only the mechanisms for guiding user interaction. Similar to component three, the experiments that we conducted provide additional valuable feedback regarding the usability of the system and again serve as a stress test of the prototype. This additional usability feedback serves to improve the overall implementation of the TEXO Innovation Repository.

7.4.1 Aim and Scope

With increasing number of ideas posted in an open innovation portal (e.g., My Starbucks Idea contains several thousand ideas) it becomes more and more difficult to nearly impossible for users to gain awareness of what ideas already exist and how their own knowledge could contribute. As ideas are submitted independently and users are unaware of existing contributions, this results in redundant ideas. Kornish/Ulrich (2009), for example, report

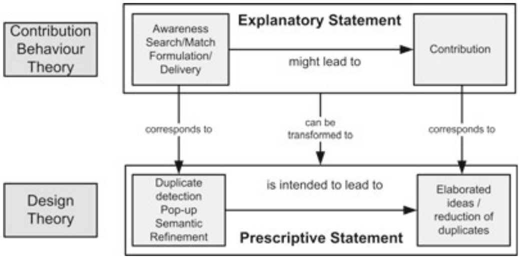


Figure 7.47: *Design theory for the fourth prototype component.*

that up to 32% of the ideas within an idea pool are duplicates. Furthermore, organisation's absorptive capacity regarding the assimilation of external knowledge is limited (Cohen/Levinthal, 1990). Consequently, companies cannot adopt all the ideas that they collected. In a detailed analysis of Dell's IdeaStorm innovation community, Di Gangi/ Wasko (2009) conclude that the main inhibitor of a host organisation adopting ideas is the inability of the idea generation community to consolidate and refine their ideas to such a degree that they can easily be adopted. That means, online innovation communities suffer from raw ideas that lack detailed descriptions and are poorly elaborated. Overall, organisations are faced with severe problems to organise the many contributions generated through the integration of external actors (Phang/Kankanhalli, 2008b). This results in a design challenge: how can organisations motivate a group of contributors to collaborate to elaborate ideas in detail? To address this issue, we want to formulate the following design hypothesis.

Design Hypothesis Through the change of contribution paths from individual idea submission to collaborative idea elaboration it is possible to improve the quality of an overall idea pool.

The goal of component four is not to improve the quality of individual ideas but rather to improve the quality of an overall idea pool through 1. reducing duplicates and 2. elaborating ideas (i.e., providing detailed, clear idea descriptions).

The aim of prototype component four is to build a mechanism to guide users in order to help them make more valuable contributions to an idea pool, thus evoking user's generative capacity. The prototype should then help to avoid redundant contributions and motivate users to engage in developing more detailed and complete idea descriptions. The fourth component thus implements a generative capacity feature: a mechanism to guide and channel user contributions in order to avoid duplicates and increase idea elaboration in the TEXO Innovation Repository. Using contribution behaviour theory we design and implement a novel, non-intuitive mechanism to guide user interaction. The core element of this mechanism is a specialised clustering algorithm that allows us to detect similar ideas in online innovation communities. In the subsequent evaluation of our system design in a laboratory experiment we evaluate whether our system is able to start the necessary cause-effect chain of the contribution behaviour theory. Figure 7.47 gives an overview of the mapping of the cause-effect relationship on the means-end relationship for the fourth prototype component.

Cause-Effect We use contribution behaviour theory (Olivera/Goodman/Tan, 2008) as the kernel theory for our theory-driven design. Contribution behaviour theory helps to understand users' contribution behaviour in the context of distributed groups where contributions occur through information technologies (as is the case in online innovation communities). The theory groups five request and five technology characteristics in three mechanisms that influence contribution behaviour: awareness, search and match, and formulation and delivery. This can be expressed as a cause-effect relationship: awareness, search and match, and formulation and delivery ⇒ contribution. Due to its fundamental importance to the design of component four, contribution behaviour theory is explained in more detail in Section 7.4.2.2 below.

Means-End The aim ("is end") of the design theory has been expressed above as: elaborated ideas and a reduction of duplicates. This matches the effect of contribution theory to elicit user contributions. To start the causal process we need to implement corresponding means, i.e., system functionality, to support the three mechanisms influencing contribution. We implement a clustering algorithm to detect existing ideas in the idea pool in order to achieve *awareness*, *searching and matching* is facilitated through a pop-up window, and to support *formulation and delivery* we employ an approach based on Semantic Web using the Idea Ontology. Subsequently, we evaluate the implemented means in order to analyse if they were able to start the causal process of contribution behaviour theory.

7.4.2 Related Work

Several general concepts are important for the design of component four. The following sections introduce the concepts of idea elaboration, the contribution behaviour theory, and clustering in the context of idea generation.

7.4.2.1 Idea Elaboration

Innovation processes are commonly structured along four steps: idea collection, idea elaboration or concept development, idea evaluation and selection, and idea implementation (Osborn, 1963; Cooper, 2008; Terwiesch/Ulrich, 2009). The aim of idea collection is to collect as many ideas as possible following the assumption that quantity breeds quality. Thus, the chance of an idea collection to contain good ideas increases with the number of ideas (Osborn, 1963). Idea elaboration becomes necessary as idea collection focuses on the generation and collection of ideas, not on the elaboration. Consequently, collected ideas lack details describing the idea to allow adequate idea evaluation and selection. The third step reduces a pool of ideas to the most promising through evaluation and selection. This step becomes necessary as implementation resources are usually limited and not all ideas can be implemented. In the last step, the selected ideas are implemented.

A more general distinction in innovation processes is that between a converging phase and a diverging phase (Osborn, 1963; Guilford, 1967; cf. also Section 4.2). In the diverging phase one moves from a state of having fewer concepts to a state of having more concepts;

in the converging phase one moves from a state of having many concepts to a state of having viewer concepts (Briggs/de Vreede/Nunamaker, 2003). Converging phases comprise steps like screening, selecting, and evaluating alternatives. The converging phase may also include necessary idea elaboration to gain additional focus and understanding of ideas. As the number of ideas generated usually exceeds the number of ideas that can be implemented, ideas are evaluated and the most promising candidates are selected for implementation. Another reason for idea evaluation and selection is that companies employ a threshold denoting what they deem a valuable idea and ideas evaluated below this threshold will not be implemented (Cooper/Kleinschmidt, 1991).

Idea elaboration is one of the most important indicators for idea quality (Dean et al., 2006). Elaboration refers to how well an idea is thought-out and whether it has a complete and detailed description (Dean et al., 2006). Elaboration is an important criterion since ideas that are unclear, vague, incomplete, or that contain unclear causality, are less useful than ideas that are more specific. In literature related to the measurement of idea quality different constructs are used to refer to the concept of elaboration: *elaboration and synthesis* (Besemer/Treffinger, 1981), *thoroughness* (MacCrimmon/Wagner, 1994), *specificity* (Dean et al., 2006), *how well described* (Cady/Valentine, 1999), or *detail, depth, and clarity* (Durand/VanHuss, 1992). A similar concept is used, for example, by U.S. Patent Office specifications, which require ideas to be "full, clear, concise, and exact" (without author, 2008). Elaboration is important because it is difficult to judge the full quality of an idea on other aspects such as novelty or creativity if the idea is poorly elaborated, incomplete, and of narrow coverage (see Section 7.3.2).

According to Dean et al. (2006), specificity can be decomposed into three aspects.

Implicational explicitness: the degree to which there is a clear relationship between the recommended action and the expected outcome.

Completeness: the number of independent subcomponents into which the idea can be decomposed, and the breadth of coverage (who, what, where, when, why, and how).

Clarity: the degree to which the idea is clearly communicated with regard to grammar and word usage.

The process of idea elaboration benefits tremendously from collaboration of several team members. Collaboration has been found to have two important effects on idea quality (Singh/Fleming, 2010). First, collaboration reduces the probability of very poor outcomes because of more rigorous selection processes. Second, collaboration increases the probability of extremely successful outcomes because of greater recombinant opportunity in creative search. Similarly, Blohm et al. (2011a) report a significant increase in idea quality for ideas with more than one contributor.

In summary it is desirable to have first well elaborated ideas (complete, detailed, and clear idea descriptions) and second have this elaboration performed by a team as opposed to a single person, a lone inventor. From this realisation, emerges the following design challenge: How can a group of contributors be motivated to collaboratively elaborate ideas rather than engaging in independent contributions.

7.4.2.2 Contribution Behaviour Theory

The theory developed by Olivera/Goodman/Tan (2008) helps to understand contribution behaviour in the context of distributed organisations. They define contribution behaviour as “voluntary acts of helping others by providing information” (Olivera/Goodman/Tan, 2008, 23). Their research focuses in particular on contributions facilitated through information technologies. Understanding how and why individuals make contributions can help to develop recommendations for designing and implementing systems that facilitate contribution behaviours. According to the model, contribution behaviour consists of three distinct activities that mediate technology’s influence on contribution.

Awareness: before a person can contribute it is critical to gain awareness of an opportunity to do so. Awareness is the cognitive activity through which a person recognises an opportunity to contribute. The activity involves attending to and evaluating the request for help.

Searching and matching: once a person has gained awareness of an opportunity to contribute, this person needs to determine whether and how the own knowledge domain relates to that of the help request, i.e., searching through personal knowledge and then matching it to the situations described by the help request.

Formulation and delivery: formulation and delivery is described as a cognitive and behavioural activity through which the contribution is articulated and communicated. The activity involves determining what specifically should be communicated and delivering it through some form of communication such as oral communication, e-mail, or posting to a discussion forum. The activities of formulation and delivery require effort.

Each of the three mediating mechanisms is influenced in turn by ten cognitive and motivational constructs that can be divided in *request characteristics* and *technology characteristics*. The five request characteristics are 1. sender status, 2. sender affiliation, 3. request domain, 4. request concreteness, and 5. request specificity. The five technology characteristics are 1. social presence, 2. synchronicity, 3. quality of search, indexing, and retrieval, 4. communication channel number and accessibility, and 5. quality of authoring tools. Influencing these characteristics by providing the corresponding IT support can be used to decrease the effort necessary to carry out the activities required to contribute. We use this model as a basis for our theory-driven design of linking independent contributions by establishing shared artefacts. The technology and request characteristics are described in more detail in the original paper (Olivera/Goodman/Tan, 2008). Figure 7.48 presents the complete model of contribution behaviour with the three mediating mechanisms 1. awareness, 2. searching and matching, and 3. formulation and delivery shown in the middle. In our work we focus in particular on the information technology effects, i.e., the technology characteristics.

Using theory on contribution behavior, redundant and poorly elaborated entries in online innovation portals can be explained by a lack of user’s awareness of previous users’ contributions. This is due to the following reasons:

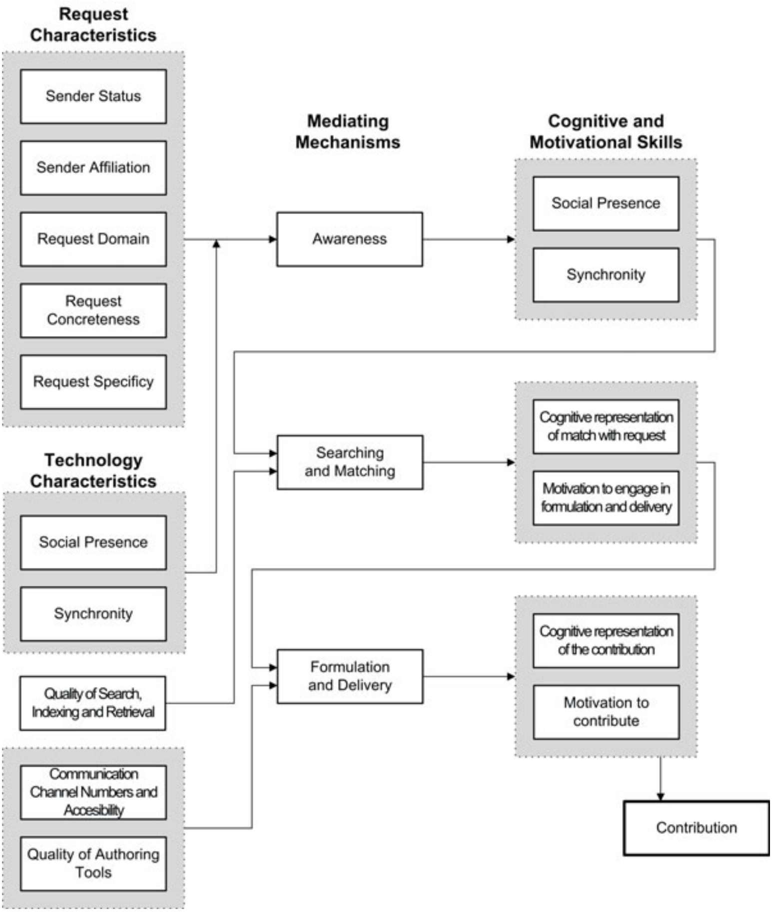


Figure 7.48: *Contribution behaviour theory (adapted from Olivera/Goodman/Tan, 2008).*

- the general and open-ended request formulated by the host-organization (e.g., "please provide feedback");
- the sheer amount of existing contributions that makes it impractical for users to screen existing contributions;
- the focus on the collection of independent contributions as opposed to establishing a community and encouraging collaboration;
- low social presence, sometimes even anonymity, in current portal designs; and
- the asynchronous communication medium.

To influence awareness it is proposed to increase social presence through the use of appropriate communication media (i.e., face-to-face rather than discussion forums) and synchronicity through the use of synchronous communication media.

In our research we use the framework of contribution behavior in multiple ways: 1. to explain why redundant and poorly elaborated contributions result from the current designs of customer feedback portals, 2. to guide our design of a problem solution, and finally 3. to contribute to the theory by suggesting the use of shared artefacts as an alternative approach to social presence and synchronicity to establish user awareness.

7.4.2.3 Clustering

Within the context of idea generation, clustering is generally considered a part of the converging phase (Chen et al., 1998; Tassoul/Buijs, 2007; Briggs/de Vreede/Nunamaker, 2003). Clustering is used as a means to structure ideas generated in the diverging phase in order to facilitate idea selection. For example, ideas can be categorised and grouped into a more manageable set of ideas. Clustering is usually performed by the group generating the ideas itself. When a group clusters or organises a set of ideas, group members develop an understanding of the relationships among the concepts. Furthermore, they can consider possible relationships among concepts and determine which relationships exists among which concepts (Briggs/de Vreede/Nunamaker, 2003). As the result of a clustering activity, a mixed list of ideas can be organised into a number of categories or arranged into a tree. As such, it is generally considered a necessary step to reduce complexity rather than a desirable activity per se (Briggs/de Vreede/Nunamaker, 2003). In summary, clustering is an appropriate means to address duplicates and redundancy. We use clustering in a completely different way by grouping ideas during idea generation rather than after idea generation. Consequently, we do not try to solve the clustering problem, but eliminate the need for it altogether.

7.4.3 System Design

Starting point of the guided user interaction is the entry of a new idea through the "post idea" function (use case "Submit Idea", Section 7.1.4.6). Before an idea is added to the database, the duplicate detection is invoked to check whether similar ideas already exist (awareness). The identified duplicates are then displayed using Web 2.0 and AJAX technology pop-ups (searching and matching) that allow convenient user interaction without the need for complete page reloading. Users can then choose a predefined contribution path to submit their contribution (formulation and delivery). The following section explains in detail how, through the process of theory-driven design, we transform contribution behaviour theory into a means-end relationship that can then be implemented as an information system, thus defining tool features to positively affect contribution behaviour on an IT level. The description will focus on the three mediating mechanisms of contribution behaviour 1. awareness, 2. searching and matching, and 3. formulation and delivery in turn.

7.4.3.1 Awareness

The size of the idea pools analysed in Section 6.3.2 range between 144 and over 83.000 ideas. In order to increase a user's awareness of ideas already present we chose to implement a duplicate detection mechanism that matches a newly entered idea to those ideas already present in the system. Thus, instead of entering duplicate and highly similar ideas while remaining unaware of existing ones the user's attention can be guided to contributions made by others. Thus, instead of contributing an idea that is already known, the user can be made aware of other ways of contributing by, for example, extending ideas contributed by others. Using detected duplicates the system formulates an automatic request for help as an alternative to submitting the entered idea to the system. The request for help is the invitation to add the idea as a refinement to one of the existing ideas. To increase the request specificity the invitation is formulated in a way that proposes a concrete mode of extending an existing idea.

7.4.3.2 Searching and Matching

To help the user search and match personal knowledge to the formulated help request we prompt the user, in a pop-up, with a list of duplicate ideas where the user can match own knowledge with existing contributions. Through a mouse-over function, the full idea description of the identified duplicates can be inspected. Furthermore, we provide a set of predefined contribution tasks, or contribution classifications, that allow the user to inject personal knowledge to previous contributions. We call this concept *contribution paths*. Information about the chosen contribution path is then stored together with the users actual contribution as a classification to provide additional information about the type of contribution being made. Our set of pre-defined contribution classifications was derived from an empirical analysis of sample comments submitted to the Starbucks and Dell's IdeaStorm portal. The following list presents possible pre-defined contribution paths resulting from our analysis:

- praise or critique to express general support or objection for an idea,
- advantage or disadvantage to collect general feedback and opinions,
- generalisation, specialisation, refinement, extension, or technical details to develop ideas further adding more details and refinements, or
- market segment evaluation, customer evaluation, or other types of evaluation to develop ideas further by collecting specific evaluation information which would usually have to be collected by internal employees or innovation managers.

Thus, our system effectively provides mental patterns of possible contribution paths. Users can thus search and match their personal knowledge with 1. the duplicate that most closely relates to their own idea and 2. the way in which their knowledge best matches existing ones by choosing from a pre-defined contribution task. This has two general benefits. First, users' generative capacity is evoked by prompting them with a more specific request. The additional request specificity results from 1. a set of existing ideas that could be extended, and 2. a list of classifications of the users own contribution (e.g., expression of an "advantage" or "technical detail"). Second, redundant submissions are avoided as users become aware of previously submitted contributions. In case a user chooses to change the contribution path, the idea is not added as a new idea but instead the idea is added as an extension, similar to a comment, to an existing idea. That means that a relationship between the original idea and the new extension is added. Furthermore, the chosen contribution path, i.e., the classification of the extension, is added as meta data to specify the type of relationship. In case the detected duplicate(s) do not adequately match the user's idea submission, we also provide the option of submitting the idea "as is" as a new, independent idea without adding a relationship to any of the previously submitted ideas.

7.4.3.3 Formulation and Delivery

Through advanced authoring tools, semantic tagging, and relating contributions to other ideas we support the user in formulating and delivering own contributions. Through the semantic tagging and the predefined contribution paths we provide effective methods to reduce mental efforts to actually formulate and deliver a contribution. In addition to selecting a predefined contribution pattern, the original idea submission can be edited to match and reflect 1. the content of the idea that is being extended, and 2. the new contribution type. Furthermore, e-mail and instant messaging links are provided to offer a variety of communication channels through which the users can start interacting with the authors of earlier contributions. These authoring and communication tools facilitate an easy delivery of the cognitive representation of the contribution.

7.4.3.4 Unintended Side Effects

A key benefit of theory-driven design is the ability to reason about unintended side effects a system might have, prior to its implementation. These unintended side effects derive directly from the theories used to implement the system. Thus, evaluation methods can be tailored specifically to examine and explore these unintended side effects that are expected to have the main negative influence on the developed system. The evaluation can thus be guided to focus on particular critical aspects rather than an integrated evaluation that would make it difficult to attribute the observed effects to individual tool features. Two main unintended side effects can be expected from our system design: motivation issues as well as difficulties in contribution compensation.

Negative Effects on Intrinsic Motivation due to Limited Attention Control Our intended system design guides users to augment, refine and enrich other people's ideas as opposed to adding own ideas. This makes self-regulation of contributors more difficult as they become subordinate contributors to other's ideas. This limited control of attention can be expected to have negative effects on motivation (Simon, 1967).

Negative Effects on Instrumental Motivation through Vexed Compensation Once several people contribute to a single idea it becomes increasingly difficult to track who contributed how much to an idea. This poses problems for awarding adequate compensation to the contributors of an idea because a variety of users may have contributed.

These difficulties of awarding compensation is has negative effects on instrumental motivation that results from a desire to obtain external rewards (Olivera/Goodman/Tan, 2008; Markus, 2001).

7.4.3.5 Design Summary

In summary, through the implementation of a duplicate detection mechanism our system design establishes awareness of existing contributions thus achieving two goals: reduction of duplicate ideas in the system and at the same time increasing idea elaboration. This increases the depth of existing ideas by guiding and channelling user contributions to the innovation process in a meaningful way. These positive effects are expected to be countered by unintended side effects negatively affecting user motivation.

7.4.4 System Implementation

This section highlights in detail the results from implementing the design described in the previous section. First, it describes how we implemented the duplicate detection algorithm which is a key component of our system design. Second, we describe the implementation of the semantic idea refinement.

7.4.4.1 Duplicate Detection through Document Clustering

While exact duplicates can be discovered by simple algorithms such as hashing, detection of so called *near-duplicates* requires more advanced algorithms (Mueen et al., 2009). Different specialised algorithms have been designed for this task, including advanced time-series analysis (e.g., Mueen et al., 2009). In order to implement the detection of duplicate ideas, i.e., ideas that are similar on a semantic basis, we chose an approach using a clustering algorithm. Clustering algorithms are well suited to detect homogeneous sets of information and are one of the core technologies in information retrieval and (Web) search engines (Manning/Prabhakar/Hinrich, 2008). Our clustering algorithm is used to group ideas into homogeneous sets and thus to detect semantic duplicates. The implemented algorithm is an adoption of a hierarchical clustering algorithm where only a fraction of the document set is actually considered (Berkhin, 2006; Manning/Prabhakar/Hinrich, 2008).

Measuring Document Similarity Our algorithm is based on the vector space model (VSM) (Salton/Wong/Yang, 1975). It describes a mapping of document sets into an algebraic vector space that enables a range of applications on these document sets. In the VSM, similarity between documents d_i is calculated based on syntactic comparison using a bag of words approach: all grammatical structure inside the document is ignored and only the number of occurrences of a term is considered. Furthermore, to treat linguistic morphology, words are reduced to their word stems, so called stemming, using Porter's algorithm (Porter, 2006). To facilitate duplicate detection in German, we also added a German stemming function. Each document D_i of the document set is then represented by a t-dimensional vector

$$\vec{D_i} = (d_{i1}, d_{i2}, ..., d_{it}) \tag{7.1}$$

where t is the number of all unique terms in the document and d_{ij} is the weight of the term j measured by the frequency of this term (the number of times a term occurs in the document), $1 \leq j \leq t$, in document D_i. For example, if $d_{ij} = 0$, term j does not occur in document i at all, while d_{ik} means that term k occurs four times in document i. Using the vector space model, similarity between two documents can then easily be calculated by the cosine of the angle (*cosine similarity*) between two document vectors $\vec{D_1}$ and $\vec{D_2}$:

$$sim(\vec{D_1}, \vec{D_2}) := \cos\ \theta = \frac{\vec{D_1} \cdot \vec{D_2}}{|\vec{D_1}||\vec{D_2}|} \tag{7.2}$$

Furthermore, we added weighted zone scoring (Manning/Prabhakar/Hinrich, 2008) to our algorithm to discriminate between similarity of idea titles and description. Zone weighting is particularly important in the context of online innovation portals where documents are comparably short. A differentiated examination of zones improves duplicate identification significantly as the following simulation shows. The variable α is used to adjust the weighting between the title and body zone. The overall similarity score between two documents is calculated as:

$$score_{weighted}(\vec{D_1}, \vec{D_2}) := \alpha * sim(\vec{D}_{1_{title}}, \vec{D}_{2_{title}}) + (1 - \alpha) * sim(\vec{D}_{1_{body}}, \vec{D}_{2_{body}}) \tag{7.3}$$

In general, the aim of clustering algorithms in information retrieval is to group (cluster) documents of a given document set into suitable subsets. The objective is to create clusters that feature a high intra-cluster but low inter-cluster similarity. At the heart of our hierarchical clustering algorithm is a similarity matrix that holds pre-calculated cosine similarity values of all documents. An idea is considered as a semantic duplicate if its similarity value with another idea is higher than μ_{sim}, defined as

$$sim_{\{i \neq j\}}(\vec{D_1}, \vec{D_2}) \geq \mu_{sim} \tag{7.4}$$

where μ_{sim} denotes the similarity threshold that decides whether two ideas are semantically duplicate or not.

Clustering Algorithm Using the similarity matrix described above, our clustering algorithm works as follows. In the beginning all documents are moved into the active set. For each document of the active set the similarity values with all other documents are compared. If the similarity value of a document s and another document o is above the predefined threshold μ_{sim} the document will be marked as duplicate. Simultaneously, the duplicate document s is removed from the active set. If, during further execution, another document r with a higher similarity value is found, the document s is considered a duplicate of r rather than the original document o and the duplicate flag is moved to this new document r (i.e., document s is moved to another cluster). In the end a cluster is defined by one document that has one or more duplicates. In a second iteration of the algorithm the centroid of each cluster is determined, added to the active set and the steps above are repeated. Due to the non-deterministic behaviour the second iteration further improves cluster quality by reassigning documents to other clusters based on the new centroid as well as merging similar clusters. Regarding the technical details, the clustering algorithm has been implemented in Java, building on the Lucene library (without author, 2009a).

Evaluation Criteria To evaluate our clustering algorithm we compared different configurations of the algorithm in a simulation regarding the objectives of high intra-cluster similarity and low inter-cluster similarity. Due to this intra-cluster view of the clustering process this criterion is referred to as an internal criterion (IC). As the intra-cluster similarity shows the coherence of a cluster, it may be used as an internal criterion for the quality of the produced clusters. Following an approach suggested by Zhao/Karypis (2002), we used an internal criterion that measures the similarity of the documents of a cluster to their cluster centroid (document). In a study of eight different global criterion functions for clustering large documents datasets, Zhao/Karypis (2002) demonstrate the good performance characteristics of the internal criterion that we use for our analysis. The criterion focuses on the intra-cluster similarity by maximising the following function in relation to the two configuration parameters μ_{sim} and α.

$$max\ \varphi_{IC} = \frac{1}{p}\sum_{r=1}^{k}\sum_{\vec{D}_i \in S_r} sim(\vec{D}_i, \vec{C}_r) \tag{7.5}$$

where k denotes the number of clusters S_r, $\vec{D}_i$ are the documents of the cluster S_r and $\vec{C}_r$ is the centroid of the cluster. In other words, φ_{IC} can be described as the average similarity of all clusters S_r. As the objective of the developed clustering algorithm is to produce only clusters that feature a minimum similarity $sim(\vec{D}_i, \vec{C}_r) \geq \mu_{sim}$, the formula originally suggested by Zhao/Karypis (2002) had to be adjusted by a weight for the number of documents assigned to clusters, i.e. the number of identified duplicates. Hence, p is the number of documents of the set that have been assigned to a cluster.

Simply maximising the presented function φ_{IC} is, however, not very helpful in the given context, as not all documents of a set are clustered. It would be easy to maximise φ_{IC} by setting μ_{sim} to a high level, say 0.9, identifying only identical documents (e.g., ideas that have been accidentally posted twice). Therefore, maximising φ_{IC} has to be subject to the amount of duplicates detected. The following measure has been constructed to relate φ_{IC} to p:

$$max\ \delta_w = \varphi_{IC} * log\frac{p}{\varphi_{IC}} \tag{7.6}$$

where the logarithm of the ratio of the number of identified duplicates p and φ_{IC} is weighted with φ_{IC} itself. The idea behind the logarithmic scaling is to make a large range of configuration results comparable. In this way, the logarithmic scaling punishes configurations with very high numbers of identified duplicates p and low values for φ_{IC}.

Textual Desciption of Configuration	*Configuration* α	μ_{sim}	*Result* p	s	φ_{IC}	δ_w
title + body simThreshold 0.3	0.50	0.30	72	53	0.46	1.004
2 * title + body simThreshold 0.3	0.66	0.30	93	64	0.43	0.997
only title simThreshold 0.5	1.00	0.50	68	49	0.45	0.988
title + 2 * body simThreshold 0.3	0.33	0.30	54	43	0.47	0.969
2 * title + body simThreshold 0.5	0.66	0.50	19	14	0.66	0.958
only title simThreshold 0.7	1.00	0.70	24	19	0.59	0.945
only title simThreshold 0.3	1.00	0.30	181	101	0.32	0.874
title + body simThreshold 0.5	0.50	0.50	10	10	0.77	0.856
only title simThreshold 0.9	1.00	0.90	12	9	0.65	0.825
only body simThreshold 0.3	0.00	0.30	41	34	0.41	0.817
2 * title + body simThreshold 0.1	0.66	0.10	267	117	0.27	0.813
title + 2 * body simThreshold 0.5	0.33	0.50	8	8	0.82	0.810
title + body simThreshold 0.1	0.50	0.10	265	122	0.27	0.809
title + 2 * body simThreshold 0.1	0.33	0.10	260	117	0.27	0.794
only body simThreshold 0.5	0.00	0.50	8	8	0.77	0.784
only title simThreshold 0.1	1.00	0.10	287	116	0.25	0.759
title + 2 * body simThreshold 0.7	0.33	0.70	6	6	0.90	0.743
only body simThreshold 0.7	0.00	0.70	5	5	0.93	0.679
only body simThreshold 0.9	0.00	0.90	5	5	0.93	0.679
2 * title + body simThreshold 0.7	0.66	0.70	4	4	0.94	0.592
title + body simThreshold 0.7	0.50	0.70	4	4	0.94	0.592
only body simThreshold 0.1	0.00	0.10	291	132	0.18	0.571
2 * title + body simThreshold 0.9	0.66	0.90	0	0	0.00	0.000
title + 2 * body simThreshold 0.9	0.33	0.90	0	0	0.00	0.000
title + body simThreshold 0.9	0.50	0.90	0	0	0.00	0.000

Table 7.24: *Simulation results for different configurations of the duplicate detection algorithm using our sample data set.*

Simulation Results and Final Algorithm Configuration To evaluate our clustering algorithm we collected a set of 480 randomly selected documents from the Starbucks innovation portal. To show the effectiveness in clustering ideas in innovation portals which happen to be quite short, it was important to use realistic data. Starbucks innovation portal with more than 83.000 entries generated by various users satisfied this criterion.

Based on the presented internal criterion the goal has been to find the most suitable configuration, i.e., finding the configuration that maximises δ_w. Our algorithm has two central configuration variables: the zone weighting factor α to adjust the weights of idea title and idea description, and the similarity threshold μ_{sim}. We performed simulations using five different configurations for zone weighting factor $\alpha = \{1, 0.66, 0.33, 0.5, 0\}$ and also five different configurations for the similarity threshold $\mu_{sim} = \{0.1, 0.3, 0.5, 0.7, 0.9\}$. As the algorithm's outcome depends on both parameters μ_{sim} and α we had to simulate all 25 different combinations of the two variables. Table 7.24 contains the simulation results, ordered by the scores of the internal criterion δ_w.

Figure 7.49 shows the average similarity φ_{IC} and the number of identified duplicates p for each configuration. The results show a clear hockey stickstyle curve. Not surpris-

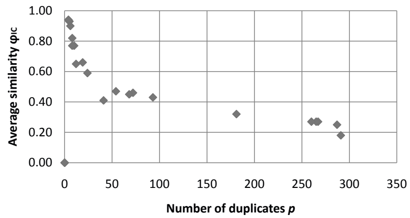


Figure 7.49: *Relating number of duplicates p to average similarity φ_{IC}.*

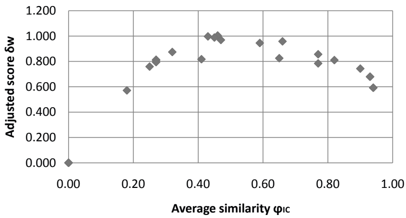


Figure 7.50: *Relating average similarity φ_{IC} to adjusted similarity score δ_w.*

ingly, average similarity decreases with the number of duplicates identified and vice versa. However, some configurations are obviously able to identify more duplicates while, at the same time, have higher values of φ_{IC} as well. Especially in the vertical segment from 50 to 100 duplicates, one can see an increased performance compared to other configurations in the first vertical segment. These are the top-performing configurations from Table 7.24. Figure 7.50 shows the distribution of configurations for the adjusted quality score δ_w and average similarity φ_{IC}. Obviously, configurations with values between 0.4 and 0.5 for φ_{IC} offer a well-balanced ratio of the number of detected duplicates p and φ_{IC} in order to maximise δ_w.

According to the definition of the presented internal criterion, all 25 configurations have been benchmarked in a simulation against each other. As the results show, the configuration with the highest value of δ_w has been achieved with $\alpha = 0.5$ (equal weight for idea title and description) and a similarity threshold $\mu_{sim} = 0.3$. This configuration detected 72 duplicates (p) in 53 clusters (s) with an average similarity of $\varphi_{IC} = 0.46$. In other words, 53 unique ideas or concepts could be identified that have 72 semantically duplicate ideas in total. Consequently, we chose a configuration of $\alpha = 0.5$ and $\mu_{sim} = 0.3$ for our clustering algorithm.

7.4.4.2 Semantic Idea Refinement

To implement the classification of different contributions along different predefined paths, we chose a Semantic Web-based approach using an ontology. Through the use of the Idea Ontology developed in Section 6 user's contributions can be classified according to predefined concepts using the `skos:Concept` class and the `hasTopic` object property. Different contribution paths can be pre-defined through modelling instances of the `skos:Concept` class. One of the pre-defined contribution paths can then be chosen for each contribution. This is stored by adding a `hasTopic` object property to the contribution, thus linking the contribution itself with an instance of a `skos:Concept` class. Table 7.25 presents an summary of `skos:Concept` instances that we used during the various piloting stages. The table highlights the breadth of potential contribution paths that can be used to guide the elaboration of ideas depending on the exact innovation scenario. In particular, critical idea evaluation criteria such as "market," "strategy," and "technology" as proposed by Bullinger (2008) can be used. For the laboratory experiment we restricted contribution paths to “advantage,” “disadvantage,” and “comment” because these are very generic and can be applied to most innovation scenarios. Furthermore, we wanted to restrict the number of possible contribution paths in order to reduce the complexity in user interaction as users worked with the system for only a very short time during the experiment itself (20 minutes) and thus had limited time exploring and learning the different system features.

Figure 7.51 shows the modelling process of the `skos:Concept` instances in the Protégé ontology modelling tool. The modelling allows the user to assign a semantic identifier, a language specific label, and a colour code for front-end display. Most importantly, the system allows this modelling during runtime. Once a new concept has been added to the ontology, it is immediately added to the system and visible in the front-end. This allows the convenient adaptation of the system to changing demands and developments in the online innovation community.

Figure 7.52 provides a screen shot of the idea submission process when at least one duplicate idea has been detected by the awareness algorithm. In this screenshot, two potential duplicates have been detected and a mouse-over effect shows the detail description of first idea. The user can chose to add the originally entered idea as an extension to one of the two ideas. The contribution paths defined through the `skos:Concept` instances is visible in the drop-down box at the bottom of the pop-up. The third submission option is to ignore the detected duplicates and submit the contribution as an independent idea.

To take full advantage of the generated refinements of existing ideas, the screen displaying the details of a submitted idea had to reflect the improved contribution mechanism. Contrary to displaying an unstructured set of comments as is currently popular in innovation portals like Starbucks, our design groups idea refinements by their semantics and the chosen contribution path. Figure 7.53 shows a screenshot of an idea detail display. Here, contributions are grouped by type and displayed in closable panels. Closable panels are a recommended design pattern to display “extras on demand” (Shneiderman, 2003) with content sections of wildly differing sizes and to allow users to open several sections at once (Tidwell, 2006). Each panel also shows the number of comments in that particular category. In Figure 7.53 the “comment” panel has been expanded.

In addition to the duplicate detection pop-up, the different contributions paths are also directly accessible on the idea detail page. Here, users can choose a specific contribution type by clicking on the respective “add” button on the left of each panel. Consequently the generic “add comment” function (Section 7.1.4.10) has been replaced with the more systematic idea elaboration option provided by the semantic refinement. Instead of the generic comment field at the bottom of the idea detail page, clicking on the “add” button now opens a pop-up in which users can type their contributions (Figure 7.54). The chosen contribution path is clearly visible at the top of the pop-up. The semantic groups thus bring structure to both, the display and the submission of contributions. As community-based idea developments often fail because the community cannot build consensus (Di Gangi/Wasko, 2009), this semantic idea refinement can provide support for additional structure within community generated contributions to build consensus.

Although unrelated to the concept of guided user interaction, the semantic idea refinement offers additional benefits for the management of a systematic innovation process.

Identifier	*Label @en*	*Comment*
http://en.wikipedia.org/wiki/Comment	Comment	A generic comment without a specific topic.
http://en.wikipedia.org/wiki/Disadvantage	Disadvantage	Idea extension that criticises an idea and points to potential disadvantages and shortcomings.
http://en.wikipedia.org/wiki/Advantage	Advantage	Contribution making positive statements about the idea.
http://en.wikipedia.org/wiki/Specialization_(logic)	Specialisation	Contribution providing more specific refinements of an idea.
http://en.wikipedia.org/wiki/Generalization	Generalisation	More general version or aspect of an idea.
http://en.wikipedia.org/wiki/Technical	Technical Details	Refinement of the more technical aspects of an idea.
http://en.wikipedia.org/wiki/Customer	Customer	Details regarding potential customers of service/product described in the idea.
http://en.wikipedia.org/wiki/Market	Market	Market details where the product/service could be traded (Bullinger, 2008).
http://en.wikipedia.org/wiki/Strategy	Strategy	Analysis of strategic fit of the idea with company strategy (Bullinger, 2008).
http://en.wikipedia.org/wiki/Technology	Technology	Technology details how the idea could be implemented (Bullinger, 2008).
http://en.wikipedia.org/wiki/Business_model	Business Model	Rationale of how an organisation creates, delivers, and captures value.

Table 7.25: *Semantic idea refinement examples used in piloting.*

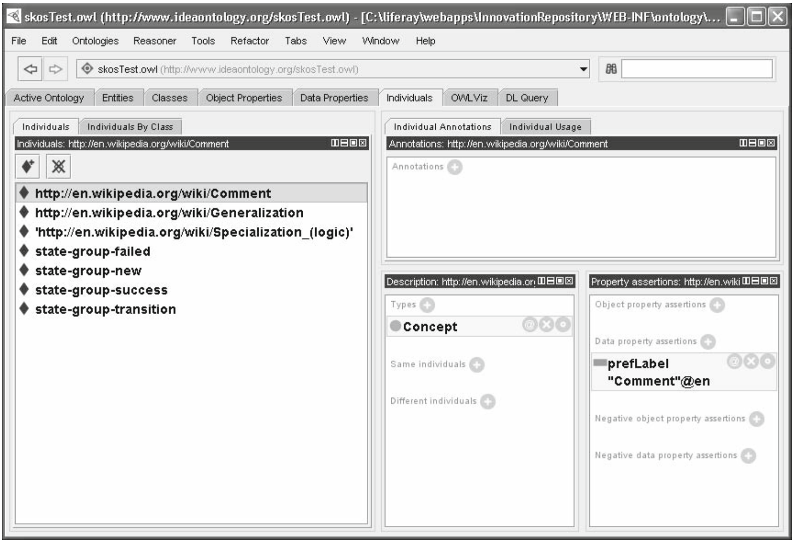


Figure 7.51: *Modelling semantic refinement in the Idea Ontology using Protégé.*

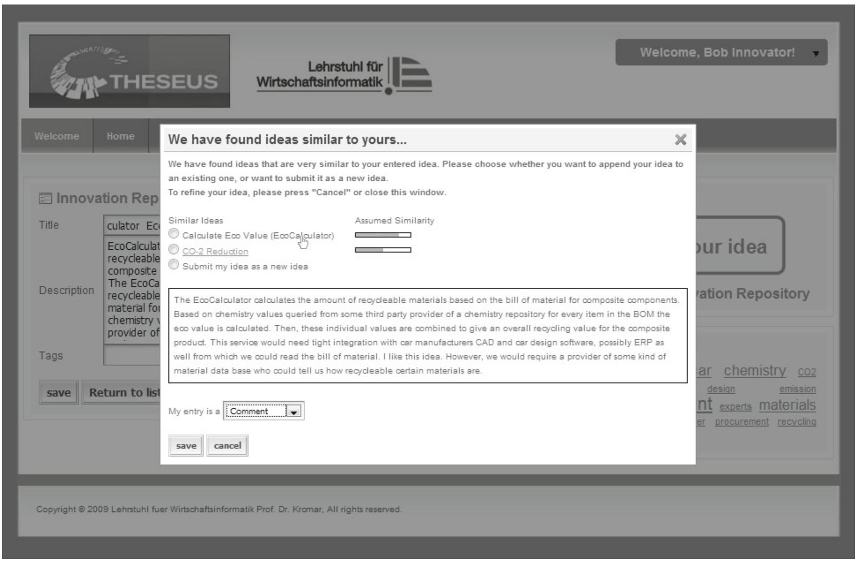


Figure 7.52: *Pop-up showing detected duplicates after an idea has been submitted.*

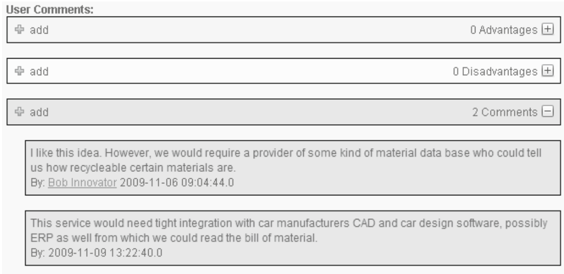


Figure 7.53: *Semantic commenting with an expanded "Comments" panel showing two comments.*

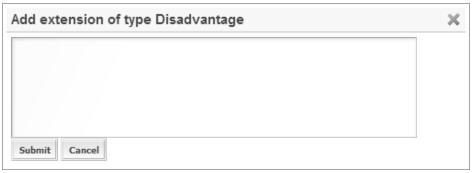


Figure 7.54: *Adding a new contribution to an idea replaces the old comment box.*

To benefit from the newly implemented semantic idea refinement, we added a maturity meter to the management function ("Idea Administration" use case, Section 7.2.4.7). We implemented a simple maturity formula which calculates a maturity value ranging between 0...1 for each idea which is displayed as a completeness meter in the Idea Admin Portlet (Figure 7.55).

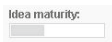


Figure 7.55: *The maturity meter based on the "progress indicator" design pattern.*

The maturity meter allows pushing ideas through the innovation process because the state of elaboration is clearly visible. The maturity meter follows the "progress indicator" design pattern (Tidwell, 2006). To calculate the maturity value, we devised a simple formula to reflect the ratio between potential contribution concepts $numConcepts$ and the contribution concepts that have actually been addressed $currentConcepts$.

$$maturity := \frac{numComments}{numConcepts * 5} * \frac{currentConcepts}{numConcepts} \qquad (7.7)$$

The maturity value is normalised with the total number of comments $numComments$ divided by a limit factor. The limit is the number of semantic concepts covered by comments of a given idea multiplied by a fixed constant value of 5. That means, a maximum elaboration is assumed if five or more comments have been submitted for every possible category. Experience from the various experiments and empirical analysis indicated that an adequate elaboration is commonly achieved with around five comments. A key benefit of the formula is its dynamic nature: it scales with runtime changes to the ontology. If additional concepts are added to the ontology at runtime, this is automatically reflected by the formula and the maturity value of ideas is updated.

7.4.5 Experiment Set-Up

To evaluate our system design, in particular towards the unintended side effects that can be expected from it, we conducted a controlled laboratory experiment. This section describes the experiment set-up used and reports experiment results.

7.4.5.1 Participants

This experiment assumes the same target population as the experiment for component three. We performed trials with three groups, two treatment and one control group (total N = 15). The second treatment group was necessary due to inconclusive results of the first treatment group due to a too small group size (see Section 7.4.6.1). Our sample population consisted of undergraduate and graduate computer science and information system students, as well as research assistants from the same subject area at a large German university. Again, we considered computer science/IS students and research assistants to be appropriate subjects for this study because they are familiar with a variety of computer systems. Table 7.26 summarises the demographic profile of the study participants.

Participants took part in only one group (between subjects design) and membership to either control or treatment group had not been revealed to the participants. With the aim of avoiding potential bias in regard to user behaviour, the study was presented as a study on idea quality in innovation portals, not mentioning the duplicate detection aspect. As most participants' native tongue was German, the study took place in German language. This means that the task itself as well as the entered ideas have been formulated in German. Participants were asked to generate ideas (brainwriting) without interaction with other participants (nominal groups; Diehl/Stroebe, 1991; Rickards, 1999) with the following task description:

> Find about 10 ideas that can help you to save energy at home.

The idea generation sessions were held in a computer laboratory with identical PCs. Each idea generation session lasted exactly 20 minutes.

7.4.5.2 Experimental Task and Design

The objective of the study has been to simulate an innovative setting, typically found in the context of innovation portals. To properly test the effectiveness of the developed duplicate detection mechanism, one would need an already existent set of ideas that is large enough to have realistic probability of users entering duplicates (as the analysis by Kornish/Ulrich (2009) showed, this could be up to 32%). As we did not have access

N	15
Age Groups	16-25 Years: 80% 26-35 Years: 20%
Gender	Male: 60 % Female: 40 %
Education Level	A-Levels: 73.3 % Bachelor: 13.3 % Master: 13.3 %

Table 7.26: *Participant demographics.*

to such a data pool, we chose a simple brainwriting, nominal group setting where users were asked to generate ideas for a pre-defined topic starting with an empty idea pool. This, however, reduced the likelihood of encountering duplicates as the first ideas to be entered have a very low probability of being similar to a previously entered idea. Obviously, the idea generation topic should leave little room for ambiguity, ensuing that users enter at least some duplicate ideas. As participants were students and researchers with various academic backgrounds, a common topic had to be found. Following current, general developments, we chose private, domestic energy consumption as the topic for idea generation. Following this approach, it can be assured that the effectiveness of the duplicate detection mechanism can be tested, while still preserving a typical innovative idea generating setting.

As in the evaluation of component three, we followed a multi-method approach (Sharma/ Yetton/Crawford, 2009) and collected data from two independent sources. First, we measured the number of ideas generated, the number of detected duplicates (and thus pop-ups displayed to users), and the number of accepted duplicates directly through system usage during the experiment. Second, we collected users' self-reported perceptually anchored measures of usefulness, ease of use, and satisfaction through a questionnaire distributed after the experiment.

7.4.5.3 Questionnaire

After the experiment, we collected data regarding user's interaction with the system through an online questionnaire (Appendix C). Based on the well established IBM Computer System Usability Questionnaire (Lewis, 1993) we collected perceived usefulness, perceived ease of use, and user satisfaction. The scale has rigorously been evaluated and is well accepted in human-computer interaction research. Similar items are also used in the evaluation of system usage by Davis (1989). All items were measured on a 5-point Likert scale. As some items did not apply to the control group, these items were optional and no measurements were collected. In the item summary in Appendix C these items are marked with an asterisk.

	Control Group			*Treatment Group 1*			*Treatment Group 2*		
Idea	*N*	*Mean*	*SD*	*N*	*Mean*	*SD*	*N*	*Mean*	*SD*
USE1	4	2.50	0.58	4	3.00	0.82	7	2.43	0.54
USE2	4	2.25	0.50	4	3.25	0.50	7	3.57	0.79
USE3	4	3.50	1.00	4	3.25	0.96	7	2.57	0.98
USE4	4	na	na	4	3.00	2.00	7	3.86	1.07
USE5	4	na	na	4	3.00	2.16	7	3.86	0.69
USE6	4	na	na	4	3.25	2.22	7	3.57	0.79
EASE1	4	4.75	0.50	4	3.25	1.71	7	4.86	0.38
EASE2	4	na	na	4	2.50	1.04	7	4.71	0.49
SAT1	4	4.50	0.58	4	3.00	2.16	7	3.86	0.90
SAT2	4	4.25	0.50	4	2.50	1.73	7	3.71	1.11
SAT3	4	3.25	2.22	4	4.50	0.58	7	4.00	0.82
SAT4	4	na	na	4	3.00	2.16	7	3.43	1.13
SAT5	4	na	na	4	2.50	1.92	7	3.57	1.51
SAT6	4	na	na	4	3.00	2.00	7	4.00	0.82

Table 7.27: *Descriptive analysis of questionnaire data.*

7.4.6 Artefact Evaluation

We performed our data analysis using PASW Statistics 18.0 (formerly SPSS). Table 7.27 shows a descriptive analysis of the questionnaire data. As only 4 duplicates were generated in the first treatment group, we restrict our analysis to the second treatment group. The following sections present the analysis of system usage data, the quality of the clustering algorithm, and our design hypothesis regarding an increased quality of the overall idea pool.

7.4.6.1 System Usage

Table 7.28 summarises the experiment results recorded by the system (actual system usage). The first treatment group generated 40 ideas, but only 4 duplicates were detected. Of these, none were accepted by the users. Due to the small number of generated ideas, we conducted a second experiment (treatment group 2) with more participants (N = 7). During the idea generation of the second treatment group, a total of 73 ideas were submitted. Among these 73 ideas, our system detected 27 duplicates. Following the detection of a duplicate, the pop-up window shown in Figure 7.52 was displayed 27 times, asking users to refine their idea submission. Of these 27 detected duplicates 19 were accepted, thus changing the contribution path from a new idea submission to the submission of a refinement comment. This accounts for 70.37% of all detected duplicates. For the remaining 8 ideas the contribution path was not changed and ideas were added to the system as independent ideas. As the effect of the active duplicate detection could be proved and quantified, the criterion of internal validity seems to be fulfilled.

	Control Group	*Treatment Group 1*	*Treatment Group 2*
Participants	4	4	7
Ideas Generated	41	40	73
Ideas per Participant	10.25	10	10.43
Duplicates Detected	N/A	4 (10%)	27 (36.99%)
Suggested Duplicates Accepted	N/A	0	19
Percentage of Duplicates Accepted	N/A	0%	70.37%

Table 7.28: *Results of the guided user interaction experiment.*

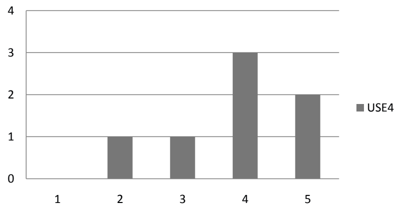


Figure 7.56: *Positive duplicate detection evaluation item USE4 (histogram; 1 = strongly disagree; 5 = strongly agree).*

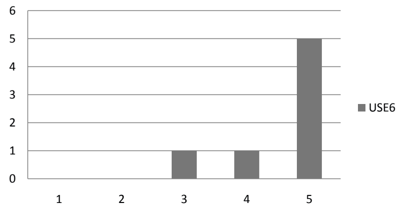


Figure 7.57: *Positive duplicate detection evaluation item USE5 (histogram; 1 = strongly disagree; 5 = strongly agree).*

7.4.6.2 Quality of Suggested Duplicates

One major driver for the effectiveness of an active duplicate detection is the quality of suggested duplicates. Evaluating whether the suggested duplicates are perceived as relevant for the user's input idea is therefore of high interest. An additional quality criterion is whether the order in which the suggested duplicates are ranked matches the user's perceived relatedness to the entered idea. We measured the quality of the duplicate detection and ranking of the using items USE4, USE5, and USE6 (Figures 7.56, 7.57, and 7.58). The analysis shows that 71% of the participants either agreed or strongly agreed to the usefulness of the suggested duplicates (USE4 and USE5). Furthermore, 86% of the participants either agreed or strongly agreed with an adequate ranking of the detected duplicates (USE6). This agrees with our simulation results and the actual system usage and overall good duplicate detection is supported.

7.4.6.3 Improved Quality of Idea Pool

To measure the quality of an overall idea pool, we have to consider the quality of individual ideas in that pool. In the context of open innovation communities, the best ideas would be those creating the highest profits after having been implemented by the company. However, this true idea quality is a priori unknown and is obviously very difficult to evaluate. Therefore, to test the stated improved idea pool quality hypothesis, we used a subjective criterion. Subject to examination has been the participant's perception regarding an improved idea pool induced by the developed ICT system. To test our hypothesis we used item USE2, "The application helped me to improve the quality and extent of the ideas I entered" as it directly relates the use of the IT system to the perception of the quality of the idea pool. Again, using data from treatment group 2 only, one participant disagreed, one participant was neutral, while five participants agreed with the statement. In the control group, three participants disagreed and one was neutral. The results show that in treatment group 2, 71% of the participants agreed to the fact of a quality improvement due to the active duplicate detection. In contrast 75% of the participants in the control group, which did not encounter an active duplicate detection, disagreed to the statement. As the only difference between control and treatment group has been the activation of the duplicate detection mechanism, other sources of irritation can be ruled out. Assuming stable unit treatment value (SUTVA) (Rubin, 1978) based on the assignment of participants to either the control or the treatment group, the duplicate detection's positive effect on idea quality seems to be measurable. To test the statistical significance of this assumption, we analysed the characteristics of the samples from the control and treatment group. Performing a non-parametric, two-tailed Mann-Whitney-Wilcoxon test with a level of significance of 5%, the result show a p-value of 0.025, indicating that the observation can be considered as statistically significant. Thus, the null hypothesis assuming no difference in the distributions of the control and the treatment group must be rejected.

7.4.6.4 Summary of Evaluation

We performed a multiple method evaluation of our theory-based system design using computer simulation, a controlled experiment collecting data for actual system usage, as well as user perception though a questionnaire. While results of the first treatment group had to be discarded due to the small number of duplicate ideas, results of the second treatment group support our system design. Actual system usage shows that during an idea generation session our system was able to detect 27 duplicates (36.99% of the 73 ideas generated in total). This supports our initial argument that duplicates are indeed an inherent problem during idea generation. Of the 27 detected duplicates, 19 were accepted by the users (70.73%) resulting in a changed contribution path from independent idea submission to the addition of an elaboration comment. This shows high acceptance rate of duplicates and indicates that users could successfully interact with the system and thus

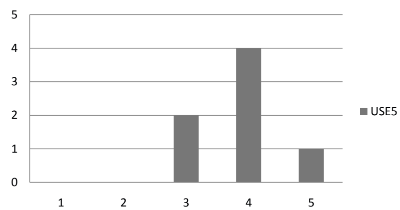


Figure 7.58: *Positive ranking quality evaluation item USE6 (histogram; 1 = strongly disagree; 5 = strongly agree).*

engage in idea elaboration. Furthermore, evaluation of actual system usage shows that our program was able to start the causal process of awareness, searching and matching, and formulation and delivery.

Regarding the analysis of the questionnaire data, a good detection and ranking quality of the duplicate detection algorithm can be assumed. 71% of the users agreed, or strongly agreed with good duplicate detection, even 86% of the users agreed, or strongly agreed with the correct ranking of the duplicates. Overall, this is in accordance with the actual system usage where only 29.27% of detected duplicates were rejected by the users. Consequently, the good quality of the duplicate detection mechanism is supported. Furthermore, nonparametric tests supported a statistically significant perceived improvement in idea quality in the treatment group on a level of significance of 5%. This is also in agreement with our algorithm simulation which confirms good clustering performance. In summary, the different measurements agree and support each other, and a good system design and implementation of the duplicate detection algorithm can be confirmed. Overall, the system was able to start the causal process predicted by contribution behaviour theory. Based on this multi-method analysis of the guided user interaction the following implication for the system concept can be expressed.

Implications for the System Design The use of a mechanism to guide users to make more useful contributions to an idea pool is an effective way to reduce the number of duplicates in an idea pool and improve idea elaboration. Such a method should be added to the basic design of the IT system supporting online innovation communities.

Due to the small number of samples, statistical inferences for generalisations of the observed results cannot be derived. However, the high approval for all three measurements (computer simulation, actual system usage, and perceived quality of duplicate detection and perceived improvement of idea quality) indicate a well-balanced configuration of the overall system design to support the three mechanisms influencing contribution in contribution behaviour theory:

- the duplicate detection algorithm works reasonably well to establish awareness of previously posted ideas,
- the pop-up helps to facilitate searching and matching, and
- the implementation of semantic idea refinement supports idea formulation and delivery along pre-defined contribution paths.

Regarding our reasoning about unintended side effects, the negative effect of limited attention control can also be confirmed by our personal experience during the laboratory experiment. As one participant fittingly expressed in the second treatment group “but this is my idea” the motivation to contribute may decrease when users are asked to elaborate other user’s ideas instead of making their own submissions.

7.4.7 Discussion

This section presented the detail design, implementation, and evaluation of component four, a mechanism to guide user contributions in online innovation portals. As mentioned in the introduction, our research related to component four serves three goals.

Implementation of a Generative Capacity Feature Based on the initial observation that pools of ideas collected by online innovation communities suffer from duplicate and poorly elaborated ideas, we tried to develop an IT system to address this shortcoming. Prototype component four presents our approach for a new kind of IT system to support idea elaboration in online innovation communities. Using contribution behaviour theory as the theoretical foundation we developed system features to address the three mediating mechanism suggested by the theory: awareness, searching and matching, and formulation and delivery. To achieve awareness of possible contributions, we implemented a clustering algorithm, to support searching and matching we designed a pop-up, and to support formulation and delivery we devised pre-defined contribution paths based on Semantic Web features provided by the Idea Ontology (Chapter 6). The guided user interaction adds a feature to evoke users' generative capacity and thus increases the generative fit of the overall system design (Chapter 5). Consequently, together with the implementation of an operational efficiency feature by component three this presents an adequate blend between the two task-related performance types which satisfies criterion C7.

Theoretical and Practical Implications From a theoretical perspective, our design extends information retrieval research through our development of a specialised clustering algorithm to achieve effective, real-time duplicate detection in the context of online innovation communities. The algorithm addresses special requirements like partial clustering and effective clustering of very short documents (i.e., ideas). Our research is the first to address this specific issue. Through extensive computer simulation and empirical user evaluation, we were able to demonstrate the effectiveness of our algorithm. Using the specialised cluster technique as a core component, we presented a novel approach to guide and channel user contributions in online innovation communities. The subsequent evaluation of the overall guided user interaction approach in a controlled experiment shows that through the use of a clustering algorithm, duplicates could be detected during idea submission and thus user contributions could be channelled in a meaningful way. Thus it was possible to achieve idea elaboration without incurring common collaboration efforts. As for component three, our multiple method approach of system evaluation provides reliable results and confirms the usefulness of our design. Furthermore, this multi-method approach exhibits a low susceptibility to common method variance (Sharma/Yetton/Crawford, 2009). In summary, our design hypothesis formulated in the introduction of component four has been corroborated.

As argued by Briggs (2006) the use of theories during the design process often leads to better and sometimes non-intuitive system designs. Our system design is non-intuitive regarding three different aspects. First, clustering of ideas is commonly only performed after idea generation to structure the output in order to facilitate idea selection (van Gundy, 1988; Osborn, 1963; Briggs/de Vreede/Nunamaker, 2003; Tassoul/Buijs, 2007). Contrary to this common use of clustering, we employ clustering in order to detect duplicates during idea generation. Second, current online innovation portals focus on idea collection which results in large idea pools that exceed organisations absorptive capacity and cannot be implemented (e.g., in Dell's IdeaStorm only 0.029 percent (416) of all ideas (14,069) have been implemented[10]). Our design shifts the focus towards idea refinement and collaboration which promises to 1. reduce the number of duplicates, and 2. result in better elaboration of ideas. Third, current approaches in online innovation communities try to lower the barriers for idea submission as much as possible to maximise contribution. This results in the above mentioned high amount of low quality, poorly elaborated, and redundant ideas. Contrary to this established design pattern, our approach is more complex but promises valuable benefits through a general shift from collection to collaboration (Malone/Laubacher/Dellarocas, 2010). Building and expanding on other people's ideas has been largely removed from open innovation processes due to the tunnelled focus on idea collection. While traditional group support systems make a sharp distinction between innovation phases (generation vs. selection) the continuously running online innovation communities have to deal with ideas at different stages: some ideas need further refinement, some can already be evaluated, and others already get implemented. Our approach breaks up the strict phase oriented innovation process by focusing on the idea itself and thus brings innovation management to the idea level: every idea has its own place in the innovation process. This adds additional features to satisfy requirement C6.

Our work addresses an established and, at first sight, inherent conflict in the design of online communities. Singular, independent contributions result in redundant, raw, and poorly elaborated ideas. Commonly, the suggested solution is to collaborate to reduce duplicates and elaborate initial ideas. This, however, introduces additional efforts as participants move from simple, independent submission to collaboration. In particular, participants would have to establish shared understanding and shared material (Malone/Crowston, 1994; Schwabe, 1995). Based on contribution behaviour theory, our design offers an innovative design artefact that tries to overcome this inherent conflict through a non-intuitive application of idea clustering during idea generation. We argue that the prevention of duplicates does not decrease the quality of an idea pool as our approach does not prevent users from submitting whatever comes to their minds. The final decision regarding the contribution path (idea submission or idea elaboration) remains with the user and is only made after the initial contribution has been received.

From a practical perspective, the effective and accurate mechanism design for online innovation communities is critical to harness crowd wisdom. Current developments in open innovation lead to many successful innovation portals with several thousand of ideas. However, our initial analysis and current research by Di Gangi/Wasko (2009) and Kornish/Ulrich (2009) demonstrate that the online innovation communities currently in use have inherent limitations regarding the limited host organisation's absorptive capacity which leads to only a very small percentage of implemented ideas. If companies want to be successful on the long run, they need to move from a simple, greedy collection of all ideas to a more refined process that can help to elaborate these ideas, solicit feedback, and converge towards implementable solutions. Our tool design allows a move from mere idea collection towards collaboration (Malone/Laubacher/Dellarocas, 2009). Our research provides actionable design guidelines how computer systems that support online innovation communities could be improved through the implementation of guided user interactions.

[10]figures as of 2010-05-26

Usability Evaluation Finally, the extension of the system and our experiences during the laboratory experiment further improved the overall usability of the TEXO Innovation Repository. Independent of the mechanism for guided user interaction triggered by the duplicate detection, we extended the system with semantic idea refinement. The concept of semantic refinement fundamentally changes users' interaction with the system. Instead of submitting generic comments, users can now engage in more detailed idea elaboration through making specific contributions to indicate "advantages," "disadvantages," or any other semantic concept that has been modelled in the system. We expect this function to improve the systematic idea elaboration. In summary, in component four we developed substantial additions to the system that fundamentally change users' interaction with the system. Although quite limited in the number of participants, our laboratory experiment with 15 users confirms good overall usability and stability of the TEXO Innovation Repository.

Our research performed related to prototype component four has several limitations which provide directions for future research. Due to the small number of participants in both the treatment and control group, our empirical evaluation is limited. However, due to the strong support between the different measurements we believe we were able to achieve a successful system design that is an important step in improving the tool support for online innovation communities. As argued in the system design section (Section 7.4.3.4), our mechanism for guided user interaction might introduce additional unintended side effects (negative effects on intrinsic and instrumental motivation). These have to be addressed by the overall incentive system of an online innovation community. However, we expect the effects to be of only minor influence as they affect only a narrow part of the overall system. For future research it would be interesting to more precisely quantify the quality improvements of an idea pool and the effects that such a system design has on idea elaboration. The design of our duplicate detection algorithm would also allow other alternative entry point to the overall system. Rather than leaving only the "add idea" or "add comment" options, the duplicate detection could be used to explicitly search for interesting collaboration points. Furthermore, the awareness aspect produced by the duplicate detection could be combined with other awareness and social presence systems (Köbler et al., 2010b)

7.5 Reflection of Prototype Development

This chapter presented the implementation and evaluation of the TEXO Innovation Repository. The implementation has been organised in design phases resulting in four components: an innovation portal, an innovation platform, a mechanism for idea rating, and a mechanism for guiding user interaction. Each component adds additional system functionality and together they provide a prototype system for tool-supported innovation management in service ecosystems. The implementation serves as an instantiation and proof-of-concept of the system design developed in Chapter 5 and the Idea Ontology presented in Chapter 6.

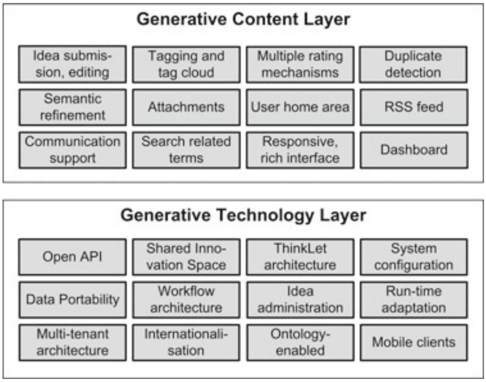


Figure 7.59: *Summary of key system features on the technology and content layer.*

7.5.1 Overall Implementation

Component One: Innovation Portal (Section 7.1) implements a base-line innovation portal which allows collaborative idea development through an online innovation community. *Component Two: Process-Based, Open-Ended Platform* (Section 7.2) provides the core technical foundation and implements key aspects of the Integrated System Design. *Component Three: Idea Rating Mechanisms* (Section 7.3) implements an idea rating mechanism to facilitate converging innovation phases to enhance operational efficiency. Finally, *Component Four: Guided User Interaction* (Section 7.4) implements a specialised algorithm to detect duplicate idea submission and allows channelling user contributions along pre-defined contribution paths. Together the four components represent a completely integrated, fully functional system to support innovation processes in service ecosystems. Figure 7.59 shows a summary of key system features organised along the generative content and technology layer.

As in all system implementations, the overall system is comprised of many individual features which make the implementation complexity hard to grasp. We therefore want to summarise the key functions in this discussion section.

- The Semantic Web approach, enabled by the Idea Ontology (Chapter 6), allows the flexible adaptation of the system. The evaluation states and contribution paths provided by the semantic refinement can be modelled in a standard ontology modelling application. Changes to the ontology are immediately visible in the system, thus runtime adaptations of the system are possible. Furthermore, the Semantic Web-based system provides advanced features such as sub-classing and reasoning.
- The system provides a process-based, open-ended, central repository that supports both generative capacity and operational efficiency features through the integration of special-purpose applications. Many special-purpose applications have already been integrated. In particular, it is possible to integrate the results of collocated workshops supported through GroupSystems' ThinkTank software, mobile applications through the iPhone, and social networks through Twitter.

- The system allows multi-stage innovation processes. This is supported by its own workflow system and the implementation of a composite thinkLet architecture. The workflow system includes process modelling through drag-and-drop in the front-end, control of process execution, and independent configuration of each process phase.

- The system offers an effective idea evaluation mechanism which allows a community of non-experts to achieve similar evaluation results than a group of experts. As no theories existed that could be used to guide the design of the rating mechanism, we developed three different mechanism which we then evaluated in an experiment with 313 participants. In this experiment, the complex rating mechanism achieved the highest rating accuracy.

- The design of the duplicate detection algorithm presented a major engineering challenge. As idea descriptions are usually very short, unstructured text generated by a variety of different users this presented special requirements and standard clustering approaches could not be used. Furthermore, our duplicate detection required that not the complete idea pool be clustered but duplicates to a given idea are retrieved. The evaluation in a laboratory experiment confirms the good quality of the duplicate detection and the overall benefits of the guided user interaction mechanism.

- The multi-tenant architecture allows the set-up and customisation of multiple instances of the complete TEXO Innovation Repository (portal and repository). This can be used to create multiple instances with independent configurations for experiments or, for example, for individual companies that do not want to share their idea pool with others. Thus, a "private" innovation space can be set up.

- The user interface for community and management functions follows the rich Internet application paradigm. Through the use of Web 2.0 technologies such as AJAX and REST the system offers users an interaction similar to desktop applications. For example, the scenario administration uses drag-and-drop process modelling and most functions are implemented via AJAX which allows fast system interaction without the need to reload the full page.

- The complete system has been tested and evaluated using real world data, for example, in the simulations performed with the duplicate detection algorithm and the rating experiment. Furthermore, the system has been piloted in various settings including experiments and industry demonstrations. This demonstrates both the flexibility and maturity of the system beyond that of a pure research prototype. Considering the empirical evaluation (measured by system usage *and* perception) the overall good quality of the system can be confirmed.

- The development of the Integrated System Design and the subsequent implementation of the TEXO Innovation Repository demonstrates the application of theory-driven system design using multiple theories over multiple design phases. This approach allows reasoning about system characteristics prior to instantiation. Furthermore, all design decisions have been rigorously documented which makes them inter-subjectively traceable. Furthermore, basing design decisions on established theories improved the overall system design and allowed us to addresses unintended side effects.

Artefact	*Type*	*Summary of Evaluation*
System Design	A/D	System implementation as proof of concept.
Idea Ontology	D	Implemented as proof of concept.
	D/E	Data mapping for different tools. Expressive enough.
	A	All competency questions can be answered.
Component One	E	Empirical collection of requirements.
	A	Functionally complete innovation portal as per requirements.
	E	Good usability (via evaluation of component three and four).
Component Two	D	Multi-tenant architecture as extension of initial system design.
	D/A	Open platform, multiple special-purpose tools have been integrated.
	D	iPhone and Twitter integration scenario.
Component Three	E	Complex rating mechanism has highest rating accuracy.
	E	5-star rating has highest user satisfaction.
	E	Overall good usability.
Component Four	S	Good duplicate detection performance of clustering algorithm.
	E	Good duplicate detection performance (system usage and perception).
	E	Perceived improvement of idea pool.
A = analytical; D = development/instantiation; E = empirical analysis; S = simulation		

Table 7.29: *Summary of artefact evaluation.*

7.5.2 Summary of Evaluation

Evaluation is of fundamental importance to design oriented research (Simon, 1969). Evaluation is necessary to document if a designed artefact does what it is supposed to do, to evaluate its utility. Throughout this research all design artefacts have rigorously been evaluated. For the evaluation of the design artefacts we used a variety of methods including system development, analytical approaches, and various forms of empirical analysis. Through the theory-driven design approach taken in this research, evaluation involves judging if the developed artefact is able start a theory's causal process rather than actual system outcome. In our evaluation, we focused on individual system aspects rather than an evaluation of the complete system in, for example, a piloting setting. This stepwise evaluation allowed us to make more detailed observations and we are able to attribute the evaluation results more accurately to the respective system features. To document the system's influence on the theories' cause/effect relationship we presented the respective evaluation results directly following the implementation. This, however, implies that the various evaluation activities are dispersed throughout the work and are not collected in a single place as is common in other works (e.g., Hoffman, 2009). Therefore, Table 7.29 collects the different evaluation results to paint a summarising picture.

Evaluation also involves comparing the objectives of the solution, as specified by the requirements, to the actual observed results from the use of the artefact (Peffers et al., 2007). The chapters on conceptual foundations (Chapter 3) and theoretical foundations (Chapter 4) presented a series of seven criteria a system to support innovation in service ecosystems should satisfy. Throughout the evaluation sections of component one through four we argued how we were able to satisfy the respective requirements. Table 7.30 compares the combined prototype functionality of the four prototype components against the seven criteria C1-C7.

Criterion	*Summary of Implementation*
C1: Support the full service lifecycle.	Satisfied through process-oriented design as well as link to idea realisation. Workflow implementation and process execution controls.
C2: Support innovation phases and rapid cycles.	Continuous innovation supported trough online innovation community. Idea generation and idea selection are supported.
C3: Provide a shared innovation space.	Repository approach and unifying framework. Innovation portal provides integrated access point for all innovation activities.
C4: Support different actors, tasks, capabilities.	Role model and dedicated system functionality for innovators and community members. The innovation portal is a collaboration system.
C5: Ability to integrate special-purpose tools.	Open REST APIs allow integration. External tools of TEXO partners, GroupSystems, iPhone, and Twitter have been integrated.
C6: Support ideas at different stages of the innovation process.	Flexible stage model through ontology and semantic refinement. Innovation management on idea level, e.g., through idea maturity model and ability to move individual ideas between phases.
C7: Fine-tune the blend between generative features and operational efficiency.	Idea rating mechanism and guided user interaction provide blend to achieve generative fit.

Table 7.30: *Evaluation of prototype against criteria for a solution (C1-C7).*

7.5.3 The TEXO Innovation Repository as a Generative Platform

The theory of generative capacity provides the central mental framework for this research. This research argued that a tool to support innovation in service ecosystems which bring together many different actors and organisations needs to be an open platform, rather than an independent tool, that supports generativity at its heart. Table 7.31 reflects on the generative aspects of the developed system. While all key generative features on the technology layer have been implemented, some generative features on the content layer could not be implemented. For example, we did not implement a specialised visualisation that would allow discovering relationships between ideas. These specialised system features were not implemented to retain a manageable overall project scope. These system features, however, can be compensated through the complete coverage of generative design directives on the technology layer (cf. Section 4.5). Here, our open, repository-based system design supported by REST APIs allows the integration of these special-purpose applications. For example, the visualization presented in the work by Riedl et al. (2010b) has been integrated with the TEXO Innovation Repository using the REST APIs. In summary, the TEXO Innovation Repository can be considered a generative platform because of its open repository architectural design and its support for key generative system functions.

Layer	*System Feature*	*Summary of Implementation*
Content Layer	D1: Visualisation	List view with sorting and tag cloud. No specialised visualisation but integration of specialised application possible.
	D2: Simulation	Simmulation not supported but available through integration of special-purpose application.
	D3: Abstraction	Tag cloud shows major topics and their relative size. Duplicate detection helps to identify collaboration points.
	D5: Communication	Multiple communication channels available including comments, e-mail, and instant messaging.
Technology Layer	D4: Integration	Repository architecture and open REST APIs.
	D6: Customisation	Multiple configuration variables and configuration templates support different uses (e.g., idea collection, idea rating, idea development).
	D7: Automation	Multiple automation functions available including: receiving up-to-date information through RSS, bulk moving of ideas between phases, advanced customisation, and awareness systems.
	D8: Peer-production	Multiple external applications integrated: ThinkTank, iPhone, Twitter, TEXO partner applications (Innovation Mining Cockpit, Service Feedback, Prediction Markets).
	D9: Rejuvenation	Open standards used: Java, Portlet system, REST API, modular design.

Table 7.31: *Evaluation of prototype against generative design patterns.*

7.5.4 Why Stop Now?

The system design presented in Chapter 5 argued that all system requirements would be satisfied after the four design phases. Requirements C1-C6 which cover the functional aspects of the overall system can clearly be regarded as adequately satisfied (cf. summary above in Section 7.5.1). But how about requirement C7 *fine-tune blend*? Component three implemented a central system feature focusing on operational efficiency in the innovation process. The rating mechanism supports a converging task, allows following a clear idea selection procedure, and focuses on efficiency and accuracy. Component four, on the other hand, implemented a mechanism that evokes users generative capacity, asks them to engage in a divergent activity, be creative, and contribute novel idea aspects thus further opening gaps. Together, however, we argue that the two features provide an adequate blend between supporting operational efficiency and generative capacity. Adjusting the blend towards either operational efficiency or generative capacity would require adapting the application to a specific situation where, from empirical observation, additional support for either of the two system characteristics became necessary. This could then be achieved by customising existing system functions (e.g., disabling idea submission to focus on idea selection) or the integration of special-purpose applications (e.g., integration of an information visualisation to discover relationships between ideas).

Furthermore, components three and four are highly interrelated. The idea rating mechanism allows evaluating and subsequently selecting the best ideas from a larger pool. However, as duplicates or very similar ideas addressing the same issue exist, the individual idea ratings are also distributed across these similar ideas. This is particularly important when, as is usually the case, not all ideas are rated by all users. In this case, not only do the duplicates obscure the true idea collection but also the collective community judgement which cannot easily be aggregated across similar ideas. Thus, the duplicate detection mechanism and guided user interaction developed in component four also improves the effectiveness of the idea rating mechanism developed in component three. Not only are idea ratings not spread across similar ideas but the additional idea elaboration also makes judging the actual idea quality more reliable. In summary, criterion C7 can also be considered adequately satisfied. Consequently all system requirements (C1-C7) have adequately been satisfied at this stage.

Finally, we have to consider the unresolved unintended side effects resulting from component four. Unintended side effects of the other design phases have been addressed by the design phase following the respective component. The unintended side effect of component four consists of negative influence on user's motivation to contribute due to limited attention control and vexed compensation. The existence of this side effect can, albeit informally, be confirmed by our experience from the laboratory experiments. The issue of compensation and discouragement can be countered by the design of adequate incentive mechanisms rather than technical issues. From the perspective of providing tool support for innovation management in service ecosystems the remaining side effects should be acceptable. In summary, the unintended side effects are expected to be of only minor influence. Finally, as the resulting prototype application satisfies all system requirements and the remaining unintended side effects can be accepted, the concept of satisficing (Simon, 1969) advises to stop the design process after the fourth cycle.

7.5.5 E-Service and Service Ecosystem Specific Aspects

The aim of this paragraph is to emphasise the aspects in which the results presented in this research are specific to the development of e-services in the context of service ecosystems.

First of all, the requirements for a proposed tool-supported innovation management have been derived from an analysis of new service development and service ecosystem research which makes them specific to the proposed subject domain. The requirements demand a tight integration of the complete service life-cycle into the innovation process due to e-service's reversed cost structure and the ability to collect runtime feedback which makes service consumption very transparent. This is reflected by the process-oriented, open-ended repository architecture of the TEXO Innovation Repository and the ability to integrate special-purpose applications (cf. unifying framework, Section 5.2). While process support is a generic concept which also applies to the design of products, it is particularly important for the design of services due to 1. the ability to systematically incorporating service feedback into the innovation process through an analysis of service usage information (Riedl et al., 2009b; Riedl et al., 2008), and 2. the fast cycle times (cf. Section 3.2).

Through the high degree of outsourcing and modularisation, coupled with the characteristics of service ecosystems, this research argued that e-services will be developed in a networked system that has to integrate many different actors. As a conceptual contribution we developed the collaboration framework that structures the different actors that can be found in service ecosystems and their respective contribution towards innovation (Section 5.1.1). The TEXO Innovation Repository supports this collaboration framework by providing a central communication platform that enables information exchange through the repository architectural design. Furthermore, the system explicitly offers a role model to support actors with different tasks and capabilities, an integration of multiple communication channels, and community building functions such as the user home page.

Although the Idea Ontology presented in this work is generic such that it applies also to traditional real-world (non-electronic) services or even (physical) products, its importance for e-services is greater, as in e-services all knowledge must be formalised in electronic representations to enable reasoning by means of software (O'Sullivan, 2006). Businesses offer and consume e-services to create value, to achieve their business goals, and to realise their business strategies (Rust/Kannan, 2003). Eventually, these e-services are realised by software components. A major challenge lies in ensuring that these software components are indeed a reflection of business goals and business strategies. This makes e-services a truly multidisciplinary field as the various aspects of e-services must be intertwined. Due to this multidisciplinary nature of e-services, the resulting theories, concepts, and artefacts are naturally also applicable to other domains.

In summary, the tool-supported innovation management for service ecosystems proposed in this research has been specifically designed for the development of e-services in the context of service ecosystems. This is reflected by the specific characteristics of the requirements collected from the area of NSD and service ecosystems (Chapter 4), the conceptual contributions regarding its solution (in particular the collaboration framework; Chapter 5), the Idea Ontology (Chapter 6), and the final prototype application. This, however, does not mean that most system functions would not be valuable in other contexts as well. While the results of component three and four clearly have a generic implication to online innovation communities, the overall system would be particularly suitable to the development of e-services in service ecosystems.

7.5.6 Why Would Anyone Use Such a System?

A common critique towards the open innovation paradigm is "Why would anyone share ideas?" The aim of this research is not to address this larger aspect of open innovation research. However, given the central importance of this issue some general comments regarding this point of objection seem appropriate.

First of all, the integration of external actors, in particular customers, is only one aspect of the open innovation paradigm. More fundamental is the general assumption of innovations being developed in a network of actors fuelled, among other reasons, by globalisation and increased mobility of workers. The analysis of new service development, service ecosystem, and open innovation literature, as well as the analysis of actors and their respective contributions to the innovation process clearly show that this networked innovation is likely to be the predominant form of service innovation in the context of service ecosystems. For the successful development of a service ecosystem, continuous innovation is necessary. Consequently, innovation has to be an integral part of the platform provider's strategy (cf. Section 5.3). Only through constant innovation and the development of new services can a service ecosystem be successful. In such a highly interrelated environment where outsourcing, driven by modularity of service components, plays a major role, collaboration, and the formation of strategic networks is an important capability. In this case of networked innovation, motivational aspects of the individual actors (e.g., employees, suppliers, strategic partners) are not as important. Rather, the question arises how such a group can, by technical means, be supported in the best possible way to collaborate, share information, and develop successful innovations. This research assumes a network of actors who are keen to share ideas and collaboratively develop new services which can then be offered by the service ecosystem. Our main aim is to provide adequate tool support for innovation development by these networked organisations.

Second, despite obvious arguments against sharing potentially valuable information with others, users actually do engage in it quite frequently. This phenomenon is commonly referred to as *free revealing* and is well researched and documented (e.g., von Hippel, 1988; Henkel, 2006). Fundamental motivational reasons for this form of information sharing are expectations of benefit from the resulting development (Franke/Shah, 2003), personal enjoyment (Lakhani/Wolf, 2005), or building reputation among peers (Raymond, 1999). Furthermore, users often lack the means to exploit their innovation by selling it since this would require a change of the user's functional role which is typically difficult to accomplish (von Hippel, 1988). In other instances, customers have successfully been motivated to contribute by a host organisation, e.g., through the use of monetary incentives like prizes (Ebner, 2008; Bretschneider, 2010; Blohm et al., 2011a; Walcher, 2007).

Some organisations may wish to keep their idea pool, or parts thereof, in a non-public space. This is supported by the multi-tenant architecture of the TEXO Innovation Repository which allows setting up multiple innovation spaces. These "private" innovation spaces can then be used by individual organisations to keep an idea pool private.

7.5.7 Discussion

This chapter presented the prototype implementation of the TEXO Innovation Repository. The overall aim of this chapter is to address research question three, which has two parts. First, how the theory-driven design presented in Chapter 5 can be transformed into a concrete implementation and, second, what can be learned from the implementation of the

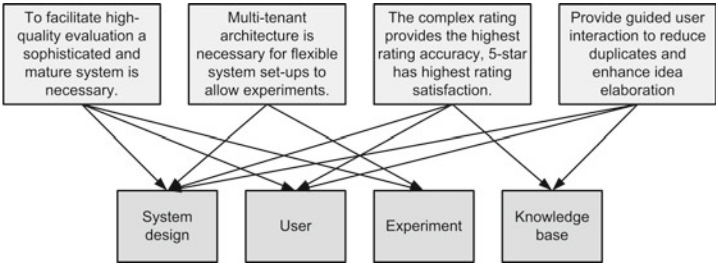


Figure 7.60: *Summary of implications and experiences from system development.*

overall system. Prototyping serves as a proof-of-concept and thus demonstrates feasibility (Nunamaker/Chen/Purdin, 1991). Furthermore, the process of building the system allows the design researcher to learn about the concepts, framework, and design as well as to gain insights about the problems and the complexity of the system. The chapter provided a detail description how the complete theory-driven design (cf. in particular Figure 5.6) has been implemented in a working system. Additional concepts such as data structures and conceptual models were developed. Through various steps of system evaluation we demonstrated a satisfactory implementation of the overall system.

Throughout the development we were able to draw several implications about the system implementation which have been noted in the respective chapters as *Implications for the System Design*. The experiences have significance on different levels which are summarised in Figure 7.60. Design implications are noted in the top row while the design targets, i.e., the areas on which the experiences have implications are shown in the bottom row. In particular component three and four make an additional contribution to the body of knowledge through the development and evaluation of novel techniques.

This chapter presented the design, implementation, and evaluation of the TEXO Innovation Repository. The next chapter elaborates this research's theoretical and practical contribution and concludes the work.

Chapter 8

Conclusion

Would you tell me, please, which
way I ought to go from here?
Alice, Alice in Wonderland.

The aim of this chapter is to discuss the analysis, design, and implementation of the TEXO Innovation Repository in the context of the challenges presented in the beginning of the research. This chapter focuses in particular on a critical reflection of the research results, the contribution to theory, and the practical implications this research has.

The chapter is organised as follows. Section 8.1 provides a short synopsis of the work and reflects the contribution to answer the three research questions posed in the introduction. Section 8.2 engages in a critical reflection of this work and evaluates the design aspects in light of Hevner et al.'s guidelines for design research. Section 8.3 summarises the research's contribution to theory. Section 8.4 then reflects on practical implications that this research has. Finally, Section 8.5 points to avenues for future research and concludes the chapter.

8.1 Summary

This research had its starting point in the challenge of developing electronic services in the context of value networks which we term *service ecosystems*. The research was guided by three research questions related to 1. the requirements that need to be fulfilled to provide tool-supported innovation management, 2. how such a system can be implemented, and 3. what can be learned from the experiences of the implementation and evaluation. Choosing a design science approach we developed tool support for innovation management in service ecosystems. Chapter 1 motivated the importance of innovation in the service sector and presented the three research questions guiding this work. Chapter 2 reviewed design science foundations with an emphasis on the integration of theory into the design process through theory-driven design. Based on this review we developed a research design guided by a combined approach of theory-driven design, theory-driven argumentation, a distinction between different outcomes of artefact evaluation, and the mapping between

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kernel theories and design theories. Chapter 3 started with an elaboration how electronic services differ from non-electronic services. The chapter then reviewed the three research areas most important to this work: new service development, service ecosystems, and open innovation. The chapter showed in particular how existing approaches of new service development do not provide satisfactory methods for the specific challenges of developing electronic services in the context of networked organisations found in service ecosystems. Thus, Chapter 3 pointed to gaps in existing research and avenues for contribution of this research. Furthermore, we derived a set of six requirements (C1-C6) for tool-supported innovation management in service ecosystems. Chapter 4 then reviewed in detail the concept of generativity and the theory of generative capacity. It introduced a basic mental framework that distinguishes between those functions of an IT system that support operational efficiency and those that support users' generative capacity. Achieving a blend between the two system functions was proposed as a sevens requirement (C7).

Chapters 5, 6, and 7 presented the central design artefacts developed in this research. Chapter 5 first developed a collaboration framework of the actors found in service ecosystems. Based on the collaboration framework the chapter then proposed a system design of a process-based, open-ended, central repository that supports both generative capacity and operational efficiency features through the integration of special-purpose applications. A key challenge arising from the system design developed in Chapter 5 is the need for a data schema that can be used by the central repository to enable the integration of external applications. Chapter 6 therefore developed the Idea Ontology which provides a defined data schema based on Semantic Web technology. Finally, Chapter 7 presented the implementation of the TEXO Innovation Repository prototype organised as four components. Component one implemented a Web-based innovation portal which serves as the central innovation space and enables communication and collaboration between the actors of a service ecosystem. Component two implemented the core concepts of the process-based, open-ended platform. Through a variety of REST-based APIs, eight external applications have been integrated into the platform. In order to provide a system feature supporting operational efficiency, component three implemented and then evaluated three different rating mechanisms. The system evaluation in a large Web-based experiment suggests that a complex rating mechanism leads to substantially better rating accuracy than do simpler rating mechanisms. In order to provide a system feature supporting user's generative capacity, component four implemented a mechanism to guide user interactions in order to elicit more valuable user contributions. The evaluation of component four suggests that the implemented mechanism does indeed reduce the amount of duplicates present in an idea pool and improves idea elaboration.

Figure 8.1 summarises the central results of the research in the context of the three research questions.

8.2 Critical Reflection

To guide the design science process Hevner et al. (2004) propose seven guidelines (cf. Section 2.2.1.3). These guidelines aim at evaluating the results of design oriented research. Table 8.1 shows the outcome of this work in the context of these design guidelines. The summary shows that this research largely satisfies the guidelines for design oriented re-

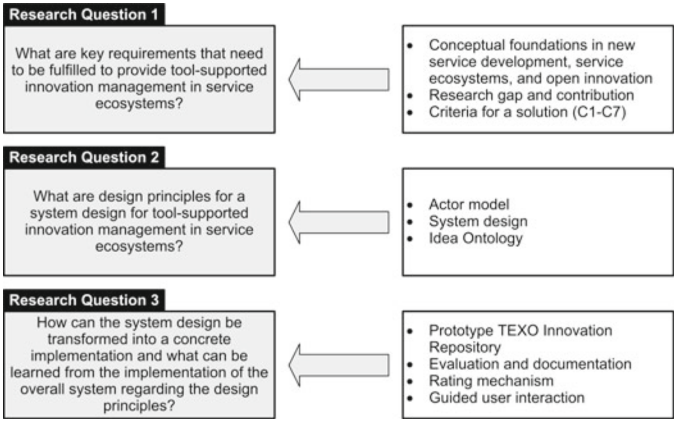

Figure 8.1: *Research results in the context of research questions.*

search. Only the guideline regarding design evaluation has to be assessed critically. The utility, quality, and in some aspects efficacy of selected aspects of the design artefacts has been demonstrated via various evaluation methods. We performed an analytical evaluation against the requirements collected through literature and empirical analysis. Furthermore, we demonstrated a proof-of-concept through an integration of eight external applications and an analytical analysis of the detailed mapping of data fields. We also performed a Web-based experiment with 313 participants and a laboratory experiment with control and treatment groups of together 15 participants. During the evaluation we relied on multiple methods for our measurements to reduce the susceptibility to common method variance. We measured in particular system usage and self-reported perceptually anchored user experience. However, the design product hypotheses regarding the system as a whole has not been fully evaluated. Overall, this research satisfies in particular the methodical aspects of the design guidelines of Hevner et al. (2004).

Up until now, the concept of theory-driven design has mainly been used for the design of individual system functions which can be mapped on a single kernel theory. However, this approach is limited when designing complex systems that may involve multiple goals and thus demand the use of multiple kernel theories. This research demonstrates an approach how this can be achieved. From a set of seven overarching system requirements and an overarching unifying framework different kernel theories have been used in four consecutive design phases to address this overall goal. Each design phase itself followed a theory-driven design using its own kernel theories. Through the use of theory-based argumentation, taking into consideration achieved system effects, unintended side effects, and unrealised effects, we designed a complex IT system for innovation management in service ecosystems. Within the scope of this work we did not demonstrate the utility of the resulting overall system, such as in a piloting setting. This, however, was a deliberate choice. Rather, we evaluated the utility of individual system functions, in particular the rating mechanism and the guided user interaction in dedicated experiments. This allowed us to demonstrate the effectiveness of these individual system features in the context of their respective kernel theories. This is only possible in the component-based approach used in this research because it is possible to control the environment and, ceteris paribus,

Guideline	*Implementation in this Research*	*Assessment*
Design as an Artefact	Resulting artefacts are the Integrated System Design, the Idea Ontology, and the TEXO Innovation Repository prototype.	fulfilled
Problem Relevance	The business problem addressed by the solution is based on critical requirements of innovation management for electronic services.	fulfilled
Design Evaluation	The utility, quality, and in some aspects efficacy of the design artefacts has been demonstrated via various evaluation methods including laboratory experiments. However, the design product hypotheses regarding the system as a whole has not been fully evaluated.	partly fulfilled
Research Contributions	The research contributes to the identified areas of new service development, open innovation, and service ecosystems. Additional contributions can be found in the various design recommendations resulting from the prototype implementation.	fulfilled
Research Rigour	A systematic research process focusing on design and kernel theories has been followed. All design decisions have been documented in the system design.	fulfilled
Design as a Search Process	A systematic research process and design guidelines have been followed while satisfying the requirements identified for the problem environment.	fulfilled
Communication of Research	Results of this research have been presented to industry partners through the context of the TEXO project as well as to the research community through publications and this book.	fulfilled

Table 8.1: *Reflection of design guidelines by Hevner* et al. *(2004).*

to isolate the treatment effect. In an integrated evaluation approach, on the other hand, it is difficult to attribute the observed effects to individual tool features due to the multitude of potential factors that influence the outcome.

This research has several limitations. A pivotal assumption of this research concerns the domain of service ecosystems. This work assumes that the trend towards platformisation continues and that service ecosystems which can only be found in a preliminary state right now will eventually materialise. However, there is growing support for the formation of platforms (e.g., Zittrain, 2008) and scholarly interest in the Internet as a service platform is increasing (e.g., Janiesch/Ruggaber/Sure, 2008; Janiesch/Niemann/Repp, 2009; Cardoso et al., 2010). Furthermore, as accepted theories on the formation of networked organisational structures, which service ecosystem are a premier example for, can be used to explain this manifestation, a growing importance of this area can be demonstrated and thus supports the relevance of this research (e.g., Peppard/Rylander, 2006; Cusumano/Gawer, 2003). Furthermore, this research does not address aspects of community building or how communities can be used for innovation and the incentive structure that would be necessary for engaging (end-)users in the innovation process. This research rather assumed an existing service ecosystem with a set of available services, service ecosystem actors like service providers, mediators, and brokers, as well as a community of users. Regarding the community building and motivation of users in open innovation, Ebner (2008) and Bretschneider (2010) can be consulted.

8.3 Research Implications

As noted in the introduction, research in information systems is inherently multidisciplinary. This is particularly the case in the area of IS research related to service science. This research is based on the scientific areas of design science, new service development, service ecosystems, open innovation, as well as related areas. Consequently, it provides contribution to these different knowledge bases. Table 8.2 gives a synopsis of all major research outcomes.

This work contributes to NSD research by extending current tools and methods for the joint development of electronic services by a network of actors. It contributes in particular in the context of networked organisations that offer and develop services cooperatively. For this cooperative development of electronic services this research proposed fundamental concepts regarding the necessary tool support (requirements) and artefacts (system design, Idea Ontology, and prototype implementation). This contribution to NSD research addresses the unique requirements and opportunities of developing electronic services in a highly networked environment.

In the area of service ecosystem research there is a conceptual gap that neglects innovation aspects. This research contributes to the field of service ecosystems by extending our understanding of innovation aspects which are currently ignored in the service ecosystem literature. This research proposed in particular a collaboration framework that systematises the diverse actors found in service ecosystems and their respective contribution to innovation activities. We introduced the view of a duality of an open and networked structure for the delivery of many electronic services and an open and networked structure for the development of these services.

This work contributes to open innovation research by extending the predominant focus from that of a single firm to that of a network of actors bound together through a central platform. We proposed a new platform perspective for open innovation that is particularly relevant in the area of service development. This platform perspective is a first step towards analysing open innovation on an inter-organisational level.

Regarding the resulting design artefacts, the Idea Ontology provides a common language to enable information sharing and to foster interoperability between innovation management tools. The specific contribution of the Idea Ontology is the description of the technical architecture in which an ontology-based approach can be applied to achieve interoperability, re-use, and structure in an inherently unstructured field.

The development and evaluation of rating mechanisms in prototype component three contributes to the body of knowledge regarding the design of innovation portals. We extend previous decision management research and offer insights into how different rating mechanisms for idea selection work within the context of online innovation communities.

Chapter	*Result*	*Type*	*Broadened Knowledge Base(s)*
2	Research design	M	Design science
3	E-Service differences	C	Service science
	Gaps in prior research	C	NSD, service ecosystems, open innovation
	Criteria for a solution	A	NSD, service ecosystems, open innovation
4	Extended view of generativity	T	Design science
5	Collaboration framework	C	Service ecosystems, open innovation
	System design	A/M	Design science, NSD
6	Idea Ontology	A	NSD, information science
7	Prototype	A	NSD
	Iterative development/ evaluation	M	Design science
	ThinkLet implementation	A	Collaboration engineering
	Multi-tenant architecture	A	Software engineering
	Idea rating	A/T	Design science, decision science
	Guided user interaction	A/T	Design science, group support systems
	Duplicate detection algorithm	A/M	Information retrieval
A = artefact; C = conceptual; M = method; T = theory			

Table 8.2: *Results of this work and contribution to knowledge bases.*

Contrary to previous approaches our results suggest that more complex rating scales should be used as they lead to improved rating accuracy. Furthermore, we showed that, using adequate tool support, a group of non-experts can achieve similar rating results as a group of experts which corroborates the wisdom of crowds paradigm.

Our theory-driven design of guided user interaction in prototype component four also contributes to the scientific knowledge base regarding the design of online innovation portals. We presented a novel use of clustering in the idea generation process. Our design based on the contribution behaviour theory promises to reduce duplicate idea submissions and to improve elaboration of ideas through guiding users in the contribution process.

This research also contributes to design science in general. We advanced the concept of basing design decisions on existing kernel theories through an example application of the theory-driven design method in a larger system development setting. Our research design extends previous design science methods by combining the theory-based design rationale process with additional concepts regarding possible artefact evaluation results. This provides a rich method for artefact design and implementation.

While the overall motivation for this research lies in the design science paradigm we relied on behavioural analysis during the evaluation of the design artefacts. Through the design aspect the following behavioural analysis can be controlled to a larger extend and thus more existing knowledge can be incorporated into the artefact evaluation. Through designing the artefacts of our evaluation ourselves, we were able to exert additional influence on the behavioural analysis and thus adjust the aspect of analysis. For example, the comparative evaluation of three different rating scales in the context of online innovation communities would not have been possible without the design aspect of implementing a computer system for this specific purpose. In summary, this allowed us to provide more adequate design recommendations for specific problem combinations and demonstrates the benefits of an integrative approach combining design science and behavioural science.

8.4 Practical Implications

The system design and the prototype application developed in this work can guide future tool developments to provide tool-supported innovation management in service ecosystems and, in particular, innovation portals supporting an online innovation community. Specifically, our research provides actionable design guidelines for community-based rating mechanisms, and for establishing awareness of previous contributions and thus channelling individual efforts in innovation portals. This addresses shortcomings of current innovation platforms on the Internet that follow a simple best-of-breed approach and sometimes include seemingly random features. Through the theory-driven approach of this research we contribute to improving these tools.

The prototype developed in this work could be taken on by a platform provider of a service ecosystem to increase the market potential of its platform. By providing members of the ecosystem with specialised tool support for innovation activities the platform provider supports them to effectively and efficiently develop new services. As the capability to innovate is becoming more important, adequate tool support that concentrates on generative capabilities rather than operational efficiency will be of great importance. The developed tool contributes in this area by focusing on supporting users on generating innovative solutions.

Experience has shown that some systems become highly successfully because they follow an open design strategy and are used in unintended ways. Users modify and appropriate different parts of a technology in ways unforeseen by the technology designers (cf. Pipek/ Wulf, 2009; Riemer/Steinfield/Vogel, 2009). Our open-ended, process-oriented platform following the unifying framework of achieving a blend between generative and operational features is intended to supports this open system usage. While the system gives some general directions for use the system can essentially be applied and adopted to a wide range of innovation activities. The open and generative nature of the system enabled by its process-oriented design and open back-end interfaces allows for an extension of the system in the context of use. Due to the duality of diverging and converging innovation activities it supports creativity without loosing the focus on operational efficiency.

Furthermore, the models and concepts developed in this research can guide companies in opening their innovation processes and implement appropriate tools that support the necessary collaboration tasks and organisational learning. The Idea Ontology can be used as an independent data format to achieve interoperability between different tools in the area of idea and innovation management.

8.5 Future Research

The limitations also serve as directions for future research and development. In the following paragraphs we propose ideas for future research in the major areas of this work.

Idea Ontology Our Idea Ontology provides a first systematic overview of the required key information for representing ideas in innovation management. In a broader sense the Idea Ontology proposed in this work is a means of supporting collaborative working environments at the semantic infrastructure layer and a key to further explore innovation processes. Future research should aim to exploit additional reasoning capabilities of semantically related subjects.

Rating Mechanisms Future research should evaluate a possible combination of a complex scale to rate idea quality and a simple promote/demote mechanism to signal popularity. Such a combination would have to provide design recommendations how the two mechanisms should be combined in case of opposing results. I.e., a highly popular but low quality idea or a unpopular but high quality idea.

Guided User Interaction For future research related to the mechanism of guiding user interaction it would be interesting to quantify the quality improvements of an idea pool and idea elaboration. Such an analysis would best be performed as a field experiment with ex-post assessment of idea quality through experts. Furthermore, our duplicate detection algorithm could be used to explicitly search for collaboration points or potential partners for collaboration.

Prototype The chain of theory-driven argumentation ends with the unintended side effects of component four. These effects could be taken up by future research that develops new theory-driven extensions of the prototype to address these unintended side effects. For example, by developing new compensation models and technical means to identify the level of contribution each user provided.

In summary, the research on electronic services and the development of these services, in particular in the context of networked organisations, is despite its increasing importance still limited. This research provides an initial basis by elaborating upon the key aspects that distinguish non-electronic from electronic services, and provides first concepts how e-services could be developed. However, several research opportunities remain. Future research in the area of e-service development could investigate in greater detail the antecedents of NSD performance that are particularly important to the development of e-services (in particular speed of development) or explore the ways outsourcing and the integration of existing service components modifies the NSD process. Furthermore, future research should investigate organisational aspects and how the network character of e-services influences the NSD process.

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Appendix A

Idea Ontology Vocabulary Specification

C. Riedl, *Tool-Supported Innovation Management in Service Ecosystems,*
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Idea Ontology Vocabulary Specification 1.0

Namespace Document 1 November 2009 - Initial Version

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Authors:
  Christoph Riedl, Norman May, Jan Finzen, Stephan Stathel, Helmut Krcmar
Contributors:
  Members of TEXO and related projects. See acknowledgements.

Abstract

This specification describes the Idea Ontology (IM) using the OWL technology. While most people have an intuitive understanding of what the terms *idea* and *innovation* mean, a precise and formal definition for the concept of an idea is hard to obtain. Nevertheless, it becomes increasingly important to close this gap. Exchanging and analyzing ideas across different software tools and repositories is needed to implement the concepts of open innovation and holistic innovation management. The Idea Ontology provides a common language to foster interoperability between tools and to support the idea life cycle.

Status of This Document

The Idea Ontology has been evolving gradually since its creation in 2008. The current state can now be considered a stable core of classes and properties that will not see too much changes in the future. New terms may be added as new requirements emerge, and consequently this specification is an evolving work. The Idea Ontology RDF namespace, by contrast, is fixed and it's identifier is not expected to change.

The Idea Ontology specification is produced as part of the TEXO project, making a contribution towards the creation of a new Internet-based knowledge infrastructure that will allow faster and more effective processing and use of online knowledge in future.

The authors welcome comments on this document, preferably via email to the authors.

As usual, see the changes section for details of the changes in this version of the specification.

Table of Contents

IM at a glance

An a-z index of IM terms, by class (categories or types) and by property.

Classes: CoreIdea | IdeaRealization | Origin | Status

Object properties: hasAttachement | hasCreator | hasForum | hasOrigin | hasRating | hasRealization | hasStatus | hasTagging | hasTopic | isNewVersionOf

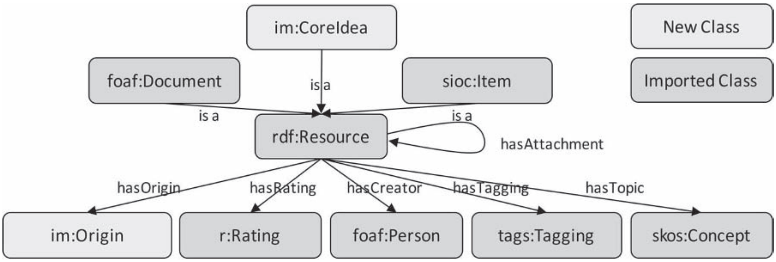
Data properties: abstract | date | description | title | version

IM overview.

Core Idea Basics

- title
- abstract
- description
- date
- hasAttachment
- hasCreator
- hasForum
- hasOrigin
- hasRating

- hasRealization
- hasStatus
- hasTagging
- hasTopic
- isNewVersionOf



Example

Here is a very basic document describing a simple idea:

```
<#idea123> a im:CoreIdea ;
        dc:title "Calculate environmental sustainability based ..." ;
        im:hasForum <#forum idea123> .
<#forum idea123> a sioc:Forum .
<http://en.wikipedia.org/wiki/Market> a skos:Concept ;
        skos:prefLabel "Market"@en .
<http://en.wikipedia.org/wiki/Customer> a skos:Concept ;
        skos:prefLabel "Customer"@en .
<#item101> a sioc:Item ;
        sioc:has container <#forum idea123> ;
        im:hasTopic  ;
        sioc:content "Automotive industries" .
<#item102> a sioc:Item ;
        sioc:has container <#forum idea123> ;
        im:hasTopic  ;
        sioc:content "Engineering departments of automobile ..." .
```

The example illustrates how the combination of im:CoreIdea, sioc:Item, and skos:Concept can be used to represent detailed idea submission forms in a semantically enriched way. We model descriptive arguments as sioc:Items that are attached to an idea and further linked to a skos:Concept through the hasTopic relationship that defines the semantic meaning of the argument. As sioc:Items are modeled as rdf:Resources it is possible to assign a rating to them.

Introduction: IM Basics

The Semantic Web

To a computer, the Web is a flat, boring world, devoid of meaning.

> *This is a pity, as in fact documents on the Web describe real objects and imaginary concepts, and give particular relationships between them. For example, a document might describe a person. The title document to a house describes a house and also the ownership relation with a person. Adding semantics to the Web involves two things: allowing documents which have information in machine-readable forms, and allowing links to be created with relationship values. Only when we have this extra level of semantics will we be able to use computer power to help us exploit the information to a greater extent than our own reading.*
>
> - Tim Berners-Lee "W3 future directions" keynote, 1st World Wide Web Conference Geneva, May 1994

IM and the Semantic Web

Several benefits can be expected by the use of an ontology. They provide structure to poorly structured or unstructured information, realize management support and interdisciplinary communication as a result of structuring information, and allow the analysis and comparison of the information represented beyond operational data. In addition to these generic benefits of representing information with defined ontologies other benefits particular important in the area of representing ideas and innovation management can be expected. As more and more idea and innovation platforms appear on the Web, it becomes desirable to exchange information between platforms and tools to prevent ideas from residing in silos. At the same time, enterprises start to understand the potential benefit from open innovation systems and feel the need to open up their internal innovation processes and to integrate innovation management tools. The semantics of an organization's specific working context is captured by its local or private ontology which serves the purposes of the particular organization. Thus, the need for a common language, i.e., a common idea data interchange format or a shared ontology to support the interoperability and to improve cross-enterprise collaboration, becomes evident.

Today, most existing idea portals on the Web are restricted to capabilities like tagging and ordinal ratings as the basis for idea analysis. However, we believe that more powerful tools and methods in idea portals cannot reveal their full potential until an agreement on the basic concepts of an idea is reached. The use of semantic techniques brings with it the possibility to improve end-user efficiency by means of automated processing, and to cope with advanced analytical processing of idea metadata through reasoning. Thus innovation managers could profit from better structured information, integration and data exchange across tools and platforms, and additional semantic reasoning that allows to analyze ideas based on related concepts.

In summary, the main benefits of using an ontology approach for idea management are the ability to achieve interoperability and technical integration between tools thus better supporting the idea life cycle from idea generation, idea evaluation through to idea implementation across specialized tools as well as advanced analysis through semantic reasoning.

The Basic Idea

We chose OWL for the development of our ontology and followed a generic ontology development approach. During our reserach we found that neither RDF as well as RDFS is not expressive enough to model complex structures like complex classes and relations carrying semantic expressions. As RDFS only supports classes and relations, it is also capable of modeling sub-class concepts and relations, but only simple ones. In the evaluation section, this will be explained with an example. We chose the approach by Noy and McGuinnes ("Ontology development 101: A guide to creating your first ontology") as it in particular focuses on the reuse of existing ontologies. Protégé has been used for modeling the Idea Ontology and an OWL version as well as sample instances for testing and evaluation purposes are available here. To further determine the scope of the ontology, a list of exemplary competency questions that a knowledge base based on the ontology should be able to answer has been designed. The questions have been prepared from the perspective of an innovation manager working with a large pool of ideas.

- Which ideas are in the repository?
- For which categories have ideas been submitted?
- Which tags have been used to classify ideas?
- Which ideas have already been implemented?
- Which ideas have at least three ratings?
- Which ideas have at least two or more ratings as well as at least one realization?
- Which are the most valueable community members by assessing at least three ideas?

The various namespaces used in the ontology are summarized in the following table.

Ontology	Prefix	Short Description
Idea Ontology	im	The ontology for innovation management introduced here
RDF	rdf	Resource Description Framework
Dublin Core	dc	The Dublin Core for metadata about resources
FOAF	foaf	The Friend of a Friend ontology for describing agents and their relationships
Tagging Ontolgy	tags	A simple tagging ontology
SIOC	sioc	An ontology for (online) communities

Rating Ontology	r	A rating ontology
SKOS	skos	An ontology for knowledge representation

IM cross-reference: Listing IM Classes and Properties

IM introduces the following classes and properties. View this document's source markup to see the RDF/XML version.

Classes and Properties (full detail)

Class: im:CoreIdea

sub-class-of:	rdf:Resource
in-range-of:	im:abstract dc:date dc:description dc:title im:isNewVersionOf
in-domain-of:	im:hasForum im:hasRealization im:hasStatus im:isNewVersionOf

This is the central class of the Idea Ontology. An `im:CoreIdea` is the entity that holds an idea. To achieve a generic and versatile representation of ideas we chose a hierarchical design with three layers of textual descriptions for a `im:CoreIdea`: `dc:title`, `im:abstract`, and `dc:description`. All three represent a textual description of the idea but vary in length and detail. Thus, our ontology is able to support very simple tools such as electronic brainstorming where an idea usually consists of no more than one sentence, up to more advanced tools that allow longer descriptions. It is also possible to extend the description with resources such as images, screenshots, or process diagrams: they can be attached as `foaf:Documents` using the `im:hasAttachment` relationship. Furthermore, every `im:CoreIdea` has an associated creation date `dc:date` and a `im:version` number to allow keeping track of different instances of the same idea by means of the `im:isNewVersionOf` relationship. An idea can also have a relationship with `sioc:Forum` (using `im:hasForum`) and `im:IdeaRealization` (using `im:hasRalization`).

Through the sub-classing attributes such `im:hasCreator`, `im:hasRating`, and `im:hasTagging` are inherited from `rdf:Resource`.

[back to top][#]

Class: im:IdeaRealization

in-range-of: im:hasRealization
in-domain-of: *unspecified (see description below)*

To support the full innovation life cycle and to allow for incremental innovations of existing products and services the link between ideas and their resulting realizations must be preserved. Moreover, the back-link from a realization to the original idea allows evaluating various performance measures. For example, it would be possible to identify authors of highly successful ideas. To achieve this tracking across the life cycle our ontology contains an `im:IdeaRealization` class which is linked to an `im:CoreIdea` by means of the `im:hasRealization` object property. The `im:IdeaRealization` class is a placeholder for whatever is an appropriate means of representing an idea's realization. In a product environment this may be a product number. In a software-as-a-service environment the idea realization could link to a description of a Web service, for example, using WSDL. The idea described in an `im:CoreIdea` may be realized as a new product or new service at a later stage of the innovation process. This class is used to link an `im:CoreIdea` to a realization of that idea.

[back to top][#]

Class: im:Origin

in-range-of: im:hasOrigin
in-domain-of: dc:source dc:title

As one of our Idea Ontology's main goals is to foster interoperability between various innovation management tools it is necessary to keep track of the application that a given resource originates from. The `im:Origin` class can be used for this purpose. In this way it can be stated that an idea originates, e.g., from a brainstorming tool, an idea portal on the Web, or another application. The application that the `rdf:Resource` originates from.

[back to top][#]

Class: rdf:Resource

in-range-of: im:hasCreator im:hasTagging im:hasTopic
in-domain-of: im:hasAttachment

Innovation related documents share certain common aspects such as having a topic or being rateable. Thus, all innovation related documents have been subsumed under the class `rdf:Resource`.
Known sub-classes within the context of the Idea Ontology are `im:CoreIdea`, `sioc:Item`, and `foaf:Document`.

[back to top][#]

Class: im:Status

in-range-of: im:hasStatus
in-domain-of: dc:description dc:title

In order to track an idea's progression throughout a submission, evaluation, and implementation process it is necessary to have states associated with an idea. The `im:Status` class offers this functionality. This class contains a set of instances denoting differnet states an `im:CoreIdea` can be in. Examples are *new*, *open*, *evaluated*, *implemented*, etc.

[back to top][#]

Data Property: im:abstract

Domain: im:CoreIdea
Range: rdf:XMLLiteral

A medium length abstract describing an `im:CoreIdea`. For a short title of an idea please use the `dc:title` attribute and for a longer description of an idea the `dc:description` attribute of an `im:CoreIdea`.

[back to top][#]

Data Property: dc:date

Domain: im:CoreIdea
Range: rdf:XMLLiteral

Time this version of an im:CoreIdea has been created.
See: dc:date.

[back to top][#]

Data Property: dc:description

Domain: im:Status im:CoreIdea
Range: rdf:XMLLiteral

An account of a rdf:Resource. dc:description is used in the Idea Ontology to assign a textual description to an im:CoreIdea and anim:Status.
See: dc:description.

[back to top][#]

Data Property: dc:title

Domain: im:Status im:CoreIdea
Range: rdf:XMLLiteral

A name given to the resource. dc:title is used in the Idea Ontology to assign a title to im:CoreIdea and im:Status.
See: dc:title.

[back to top][#]

Data Property: im:version

Domain: im:CoreIdea
Range: rdf:XMLLiteral

Every `im:CoreIdea` has an `im:version` number to allow keeping track of different instances of the same idea by means of the im:isNewVersionOf relationship.

[back to top][#]

Object Property: im:hasAttachment

Domain: rdf:Resource
Range: foaf:document

An `im:CoreIdea` (more specifically: all `rdf:Resources`) may have documents attached to it (e.g., a screenshot, a process model, technical drawings, etc.) that contains more detailed descriptions of the idea.

[back to top][#]

Object Property: im:hasCreator

Domain: rdf:Resource
Range: foaf:Person

Relates a `rdf:Resource` to its creator `foaf:Person`.

[back to top][#]

Object Property: im:hasForum

Domain: im:CoreIdea
Range: sioc:Forum

An im:CoreIdea may have multiple sioc:forums associated with it where users are discussing the idea. All sioc:items (forum style, blogs, anything) are organized using the SIOC ontology.

[back to top][#]

Object Property: im:hasRating

Domain: rdf:Resource

Range: r:Rating

All innovation related rdf:Resources can be rated. If a rdf:Resource has a r:Rating, this is indicated by im:hasRating.
See: tvblob rating.

[back to top][#]

Object Property: im:hasRealization

Domain: im:CoreIdea

Range: im:IdeaRealization

An im:CoreIdea may be, at a later point in the innovation process, be implemented in a concrete product or service. This is indicated through a im:hasRealization link to an im:IdeaRealization.

[back to top][#]

Object Property: im:hasStatus

Domain: im:CoreIdea

Range: im:Status

Every im:CoreIdea should have an assigned state which denots the state of this idea. This could mean that an idea is *open, evaluated, implemented,* etc.

[back to top][#]

Object Property: im:hasTagging

Domain: rdf:Resource
Range: tags:Tagging

Relates a tag to a `rdf:Resource`.

[back to top][#]

Object Property: im:hasTopic

Domain: rdf:Resource
Range: skos:Concept

Denots that a given `rdf:Resource` is related to a `skos:Concept`.

[back to top][#]

Object Property: im:isNewVersionOf

Domain: im:CoreIdea
Range: im:CoreIdea

To account for versioning of ideas and comments different versions of the same idea/comment can be linked to each other indicating that they are "the same" but in different versions.

[back to top][#]

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Recent Changes

2009-11-09

- Initial version

Appendix B

Rating Experiment Questionnaire

	Rating Satisfaction (5-Point Likert)
SAT1	The idea rating was user friendly.
SAT2	I am satisfied with my ratings.
SAT3	Rating the ideas was fun.
SAT4	Rating the ideas met my expectations.
	User Attitude Towards the Website (5-Point Semantic Differential)
ATT1	I found the online platform: dull/exiting
ATT2	I found the online platform: bad/good
ATT3	I found the online platform: not entertaining/entertaining
ATT4	I found the online platform: negative/positive
ATT5	I found the online platform: terrible/wonderful
ATT6	I found the online platform: rigid/flexible
ATT7	I found the online platform: frustrating/satisfying
	System Usability (5-Point Likert)
USE1	My interaction with the rating mechanism was clear and understandable.
USE2	I find the rating mechanism easy to use.
USE3	It would be easy for me to become skilful at using the rating mechanism.
USE4	Learning to operate the rating mechanism was easy for me.
USE5	I could effectively complete the task using the rating mechanism.

Table B.1: *Items measuring user satisfaction, expertise, and attitude towards the website in the rating scale experiment.*

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Appendix C

Guided User Interaction Survey

	Usefulness (5-Point Likert)
USE1	The user interface helped me to be more innovative.
USE2	The application helped me to improve the quality and extent of the ideas I entered.
USE3	The application supported me in developing new ideas.
USE4*	I found the suggested similar ideas useful.
USE5*	Suggested similar ideas were indeed similar to ideas I entered.
USE6*	The order of suggested similar ideas was matching the actual degree of similarity.
	Ease of Use (5-Point Likert)
EASE1	It was easy to enter ideas in general.
EASE2*	Choosing and selecting a suggested similar idea was easy.
	Satisfaction (5-Point Likert)
SAT1	The application worked the way I want it to work.
SAT2	I would recommend the application to a friend.
SAT3	I liked the application.
SAT4*	Finding similar ideas was fun.
SAT5*	Finding similar ideas was annoying.
SAT6*	Finding similar ideas was interesting.

Table C.1: *Questionnaire items measuring usefulness, ease of use, and satisfaction in the duplicate detection experiment. (*) Mark items that were optional in the control group questionnaire.*

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