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BUSINESS PROCESS IMPROVEMENT BY ADVANCED INNOVATION PROCESS MANAGEMENT IN SME

UDC:

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Abstract: Business process improvement, as an unavoidable component of the companies' strategy, particularly for SMEs, is deeply interwoven with innovation in general and both are conditio sine qua non for surviving and thriving in the global economy. This paper describes an approach and ICT system for supporting business process improvement following a structured way to innovation process management. The innovation process management approach based on agile principles in methodology and a corresponding ICT supporting solution is presented. Two application cases, one dealing with development and manufacturing of weighing systems against specs and regulations and one dealing with development and manufacturing of systems for Monitoring and Control of Assembly Processes in the manufacturing industry, where the system prototype was tested, are briefly described as well.

Key Words: *Process improvement, Innovation management, Decision support system.*

1. INTRODUCTION

The importance of business process improvement is nowadays very high – it can be seen as a key success factor for the next generation enterprise, particularly for SMEs. Innovation in turn, as a basic assumption for business process improvement is conditio sine qua non for surviving and thriving in the global economy.

Business process improvement's compulsory component is some form of innovation, comprising, among others, changes of organisational responsibilities, innovated activities and processes, and finishing with a better or completely new product. Management of innovation in an organisation, as the most important part of the business process improvement, is a business process in itself. This process must be prepared, defined, implemented, executed and controlled, just as with any other process [1].

In companies with long-term innovation strategy as well as in those that perform innovation "upon request", the process is composed of preparation of an innovation initiative, the ideas collection, ideas prioritisation, implementation and evaluation of the innovation and its impact upon business processes and a company's profitability as the final target [2]. In the initial phases of preparation of an innovation initiative and the ideas collection, it is of crucial importance to direct creativity during the generation of ideas to the targeted process objectives, taking care to ensure the structure necessary for a systematic innovation approach.

Innovation, as a highly important condition for the companies' survival, is given a high level of importance in a number of roadmap documents and visions of manufacturing development in the Factories of the Future. Innovation, particularly ICT supported, is a key growth factor in reviving manufacturing within Europe in the short to midterm; i.e. innovative thinking, design and manufacturing are factors of utmost importance for the growth of European manufacturing [4]. Therefore, implementation of ICT solutions to manage and stimulate innovation in industry, particularly in SMEs is very important [5].

This paper describes an approach and ICT system for supporting business process improvement with particular emphasis on a structured way to innovation process management.

The solution concept can be shortly described as a collaborative internet-based platform that implements a new methodology, based on agile methodologies, for the adoption of business process improvement, based on systematic innovation process management in globally acting networked SMEs [2], [3].

Following a short overview of recent and current works related to business process improvement in general, specifically based on innovation and innovation process management, in this introductory chapter, chapter 2 briefly summarises the general and addressed problem topics, followed by a description of the solution concept, including a short overview of the

system architecture and implemented ICT functionalities by presentation of a few Graphical User Interfaces. Chapter 2 ends with the presentation of two application cases in two SMEs.

Chapter 3 provides conclusions and future plans.

2. CURRENT APPROACHES – STATE OF THE ART

Among the several models used to address business process improvement, it is argued that one that serves as a framework for achieving results in any industry, and offers the most holistic approach to process improvement, is the Baldrige Criteria for Performance Excellence [5]. It is not new, but like any successful management method, it has been modified and refined to meet continuously changing business needs.

In the field of innovation, according to a number of industrial surveys [6], [7] a high percentage of enterprises think innovation is a key competitive advantage. It is however argued that the number of successful efforts in helping to improve innovation management across the extended enterprise is not high, and that "little attempt has been made in business and policy communities to systematically draw on concepts, theories and empirical evidence that have been developed over the past three decades of innovation studies, in order to improve the overall climate for innovation" [8].

Several publications describing, mainly experimental, platforms supporting innovation process management [7][9][10][11] are emphasising the importance of innovation ontology as an enabler of exchanging and analysing ideas and concepts across different software tools and repositories needed to implement holistic innovation management.

An application is described in [7], which includes a method added to the knowledge base able to increase effectiveness of idea assessment during the initial phase of the innovation process. Its future applications in technology-driven manufacturing SMEs, from different industries, are expected to allow for the analysis and comparison of company-specific approaches, enhancing the validity of this solution.

The general importance of a community-based knowledge management strategy, which emphasises support for informal knowledge exchange networks is pointed out. It should stimulate new ideas by supporting a climate of free knowledge exchange between individuals, directly encouraging innovation [9].

System iTeams is described in [10], which focuses on providing a knowledge management platform to develop, communicate and control innovation in a team. This system (like all others) for managing innovation in any organisation and across organisations requires each organisation to adopt the schema or ontology inherent in the system, which creates certain limitations in reflecting the expressions and terms used within different teams.

The so-called NCD-model, which provides a common language and terminology necessary to optimise the innovation process, is described in [12]. This model defines five controllable activity elements: opportunity identification, opportunity analysis, idea generation and enrichment, idea selection, and concept definition of the Fuzzy Front End.

An exhaustive study about innovation practices in European SMEs presented in [13] shows that systematic innovation controlling and learning routines seem to be the most important pre-requisites for SMEs to leverage openness for the successful launch of innovation projects, whereby internal structures and processes need to be established first. In addition, innovation processes need to be systematically aligned with internal structures and processes in SMEs, which can be expected to be successfully supported by the here presented Decision Support System for innovation process management.

BIVEE – Business Innovation and Virtual Enterprise Environment[i] is an EU project claiming that it intends to "innovate innovation". However, public results are not available as of February 2013.

3. SOLUTION

2.1. Detailed problem statement

It is argued that current innovation management techniques and organisational solutions tend to focus mainly on the hard aspects of innovation, and much less on its softer elements. It is obvious that the scope of innovation is so broad that it can be only steered and managed in an integrated way, across all of its aspects and phases.

A key phase in the innovation process, which has the highest impact on the following process steps and results, including the total innovation costs, is the early phase of the process: the so-called Fuzzy Front End of innovation. This is the phase during which the most important decisions are to be made, based, to a great extent, on (human) intuition, creativity and the "sense for innovation", which are not easy to structure and bring into a machine readable form. It makes the initial phase of the innovation process the least well-structured part of the process, both in theory and in practice [4], and emphasises the importance of an ICT solution to support management of that part of the innovation process [3]. However, keeping in mind a.m. significant influence of human participation in the Fuzzy Front End of the innovation process, it is obvious that such an ICT support system can and should be limited to Decision Support during the process.

Precise identification and structuring of relevant knowledge components, common language and terminology and sophisticated reasoning mechanisms are important assumptions for developing and implementing such an ICT Decision Support System, whereby relevant knowledge, and common language and terminology are highly dependent on the specific innovation contexts (company specifics, process/product to

be innovated, innovation drivers, etc.). Common terminology is of a very high importance for coping successfully with the large amount of data streaming from numerous sources, such as science and trade journals, public web sites, expert networks, consultants, news reports, transcripts, and published research. All of these information sources are crucial for SMEs, which commonly do not have their own R&D departments. These sources can be used for valuable ideas in the implementation of an innovation process. However, as ideas are only very rough sketches that need to be meticulously filtered, it is advisable to collect a vast number of ideas, and this can of course cause problems since one of the most challenging barriers to turning ideas into innovative change nowadays is not a lack of information, but the ability to identify quickly what is important and make actionable, insightful, and fully informed decisions. In addition, although innovation is a knowledge intensive process, it does not respond well to traditional, centralised, information-based knowledge management, which is particularly challenging in networked SMEs structures or extended enterprises. All these factors impose the requirements of appropriately linking separate data sources, providing an easy way to navigate all the innovation systems of the extended enterprise, in order to support extensibility so that they may easily add new innovation data sources in different contexts, and to provide the ability to integrate different innovation database resources with structured, semi-structured and unstructured data. [7]. The composition of activities, for a successful innovation process requires a number of things; it is necessary to 1. Monitor relevant information sources and quickly and efficiently identify new technologies and processes for product development; 2. Uncover new applications and markets for existing technologies; 3. Find potential partners and identify leading experts and competitors, and 4. Understand potential risks and benefits of new approaches in launching product/process innovation or entering new markets.

To transfer the above listed priorities into specific functionalities of an appropriate ICT system is a tough task. On the other hand, ICT innovation is a fundamental success factor for future manufacturing operations in Europe – enterprises and particularly SMEs have to be agile and swift when it comes to being innovative and applying innovation in practice since, according to current reports, innovations still take considerable time to be put into practice – from laboratory prototype to full scale production – thereby giving competitors a chance to overtake European enterprises through speed [4].

An important factor to be taken into account is innovation and innovation management in the context of a.m. networked SMEs, i.e. extended enterprises, which in turn represent a significant component of the innovation process complexity. An essential role of individual knowledge of innovation and, more specifically, of the importance of the exchange of this individual knowledge through informal face-to-face discussions in the initial phase (innovation inception), has a higher importance within extended enterprises. Independent ICT systems have no common underlying information model; sometimes much information is duplicated between them, and when one has access to information that another lacks, this cannot be shared. To cope with inconsistencies that emerge both between information models themselves and between the ways that different applications interpret the same information, an appropriate means of ICT support is highly essential.

2.2. Approach and proposed solution

For the purpose of defining the concept of a platform to support innovation management along the whole innovation process, as required by several SMEs in the project (see description of two applications below), the innovation capacity and context were identified in these SMEs and, based on this, initial needs and requirements were identified. These were further detailed in interviews within the companies and complemented with the state-of-the-art in theoretical elaborations, practical realisations reports and commercial innovation management systems.

The intention behind the selection of the approach in designing the here-presented innovation management support system, was to integrate as many existing concepts and practical solutions as possible and to create a solution affordable for SMEs, whilst also being user friendly at a low complexity level. In addition to this basic assumption, it was required that the platform supports SMEs in managing and implementing the innovation processes in networked environments, taking into account their internal and external links, by enabling an open multi-agent focused innovation (i.e. a customer/provider/supplier/employee focused innovation). The solution has to focus specifically on the needs of manufacturing companies and will observe both product and process innovation.

Besides that, the solution should focus on the initial innovation phases, mainly comprised of Inception and Prioritisation Services of the system, and result in paying specific attention to the corresponding functionalities as presented here.

The solution was required to allow for creating and integrating a component to search, raise and make available knowledge bases, including Innovation ontology.

In addition to secure access to the system by assigning roles and permissions to users, special precautions have been taken regarding security of data transmission issues, which are particularly important for innovation processes in SMEs, (for preventing leakage of confidential information related to new products) in terms of assuring implementation of protocols for secure transmissions of data (such as SSL and TSL).

Regarding the user's front end, accepted standards are used, but state-of-the-art, not yet standardised

solutions should be used as updates to ensure validity of the portal in the future.

The concept of the ICT support system included functionalities to support the most practiced Innovation Methodologies in Industry among which specifically for the inception services - Brainstorming, Brain Writing, Heuristic Redefinition Process, Transformation of Ideal Solution Elements with Associations and Commonalities. The Prioritisation Services, supposed to facilitate selection of the innovation concept, should provide functionalities for the evaluation of technical (3d simulation, virtual prototyping) and economic (profit simulation) properties of the concepts functionality to measure company's capability and resources availability for the implementation, and their filtering to determine which concepts, i.e. innovations, will enter the development stage. In order to facilitate and fasten the system realisation process, it was decided to apply the a.m. functionalities for the prioritisation process as external tools/modules for which appropriate interfaces had to be provided.

The services for the first innovation phases as well as the other two groups of services, for Implementation support and for Innovation Follow-up, are to be implemented as an SOA-based system, again using existing systems such as e.g. existing Service Oriented Architecture Implementation Frameworks (e.g. by adapting existing frameworks such as Spring Framework or others).

The concept of the whole platform, with detailed parts of the decision support system, is presented in Figure 1.

2.3. Functionalities

The Decision Support System to be used for supporting innovation process management includes a group of functionalities dedicated to the general, so-called supporting services and a group of functionalities that are specific to innovation process management.

3.3.1. Supporting Services

The functionalities enabling a virtual collaborative space are intended to enable a smooth common multitenant usage of the system, where a high number of users from single enterprises, extended enterprises and/or wider communities (open innovation) can work on innovation projects. Different collaboration patterns (synchronous, asynchronous, etc.), following assigned roles, are possible. The virtual collaborative space can be divided into independent spaces for simultaneous work on different process/product innovation projects. Access to the virtual collaborative space is via a user friendly and intuitively composed, web based graphical user interface, accessible by any Web browser.

The standard knowledge management functionalities, i.e. acquiring relevant knowledge, search for knowledge components, tracking and tracing innovation projects, reasoning methods, creation and maintenance of the innovation ontology [15], etc. are the next group of general services.

Further collaborative services are Experts search (external and internal), and Team composition and management also from external and internal staff that allow for composing ad hoc activity groups based on, for example, Purpose of team, Availability of team members, Required knowledge areas, and Personal interests.

In order to motivate employees to participate in innovation, processes services for Incentives Definition are implemented based on the number and quality of innovative ideas and preferences of successful innovative ideas proposers, in terms of identification of the most appropriate incentives.

Services for Risk Assessment are to be used in an appropriate form for both ideas prioritisation and innovation implementation. During these two phases the risks of innovative product/process failing either technically or financially are to be carefully evaluated, leading to innovation process adaptation or abandoning.

For enabling a highly-effective collaborative innovation process, the platform has functionality allowing for inputs from mobile devices.

A Common Knowledge Repository (CKR) for the whole system stores data about Ideas, including history of all ideas posted anytime in the past, Solutions, Success stories, Rules, Business and Innovation models, Company's principles and policies, Ontology, SME specific data like plant description, processes description, list of employees with related data, Product and Process related documents, with easy access to product or service improvements, including linkages to customers and suppliers and information about national and international funding opportunities to support the development of innovation project.

As an add-on to the platform functionalities for self-assessment of the capacity to carry out Innovation projects, and for self-assessment of the adequacy of the context to carry out Innovation projects, both based on the criteria Organisational policies and practices, Implementation Climate, Management Support, Financial Resources Availability/Accessibility, Learning Orientation and Managerial Patience have been implemented. All of these criteria are composed of several sub-criteria to provide a fine grained picture of the related SME status. Results of both these assessments are iteratively used in the process of adaptation of the a.m. capacity and context for innovation.

3.3.2. Innovation Management Services

As presented in Figure 1 services belonging to the decision support system for innovation process management are divided into four groups to support management of four innovation process phases:

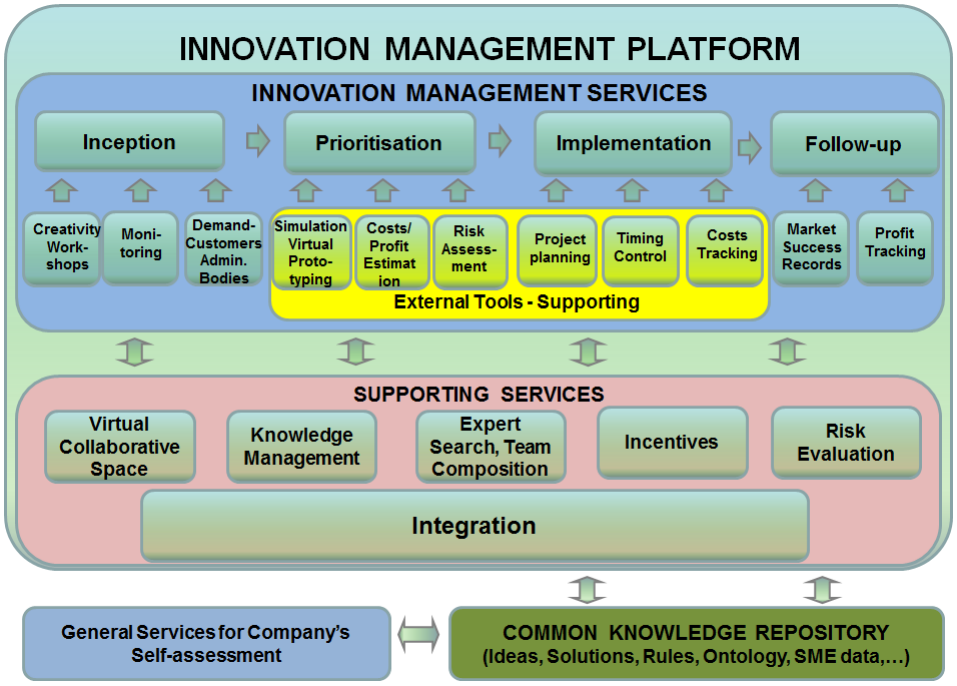

Figure 1: ExtremeFactories platform concept

Inception Services, supporting the initial phase of the innovation when innovative ideas are created and collected

Ideas Prioritisation Services, which should enable analysis of collected ideas and selection of the most promising ones based on predefined criteria

Implementation Services, which should provide support to innovation process management in terms of monitoring timing, financing, selection of the most appropriate materials/components, processes, etc.

Follow-up Services, to support assessment of success of the implementation of innovative products/processes

The functionalities, which belong to the four groups of services, are in the prototype of the system realised partly as platform internal and partly as external tools.

The functionalities supporting the Inception phase are actually supporting creativity and related events, i.e. initialising creation of innovative ideas. These functionalities are realised as a prototype version partly using concepts from available brainstorming techniques in meetings and with mind mapping.

The functionality for enabling monitoring of different data/information/knowledge sources is very important for SMEs, keeping in mind that they mainly do not have their own RTD departments, and required relatively sophisticated ICT mechanisms to be implemented.

The innovation triggers are usually divided into technology-push and demand-pull [15], [16], whereby technology-push ideas can originate from several sources. The basic group of technology-push ideas are collected from sources where news on RTD results and technology development are regularly published. These sources include scientific journals, universities' bulletins, research organisations' bulletins, leading technology development companies' publications, and others, whereby the market requirements and new products on the market are also to be monitored. To assure a fast reaction to technology-push triggers, the platform should provide functionalities for the continuous monitoring of important information sources to be used by the services, particularly in the Inception phase of an innovation process.

The monitoring functionality is based on so-called monitoring services as described in [17], via a graphical user interface that allows the definition of the data source, the frequency of the access, and the duration of the monitoring task. Specific to each data source, additional filters or search terms have to be adapted to the platform (service) to further specify the requested data, e.g.: For monitoring of new technologies: the specific technology to be considered, and a pattern that should be checked on each monitored data record; for RTD reports monitored: specific topics for any kind of e-documents monitored: keywords and/or titles of documents that are relevant/interesting for the respective SME, and for market demand and offer specific products are to be defined as well as their components.

Besides monitoring external systems, the monitoring services can also be used to access legacy systems in each company to import new data relevant for the innovation in process.

Further functionality comprised in the innovation inception services is related to the demand-pull group of innovation triggers. This functionality supports structuring of customer demands and, in some cases, also demands for the improvement of some product characteristics coming from certification bodies, to which products are submitted. Data for these function-

alities comes from legacy systems, i.e. from the companies' internal ICT systems where all kinds of requirements are stored. Corresponding innovation ideas can be inserted into the system by corresponding users, mainly from the company design department.

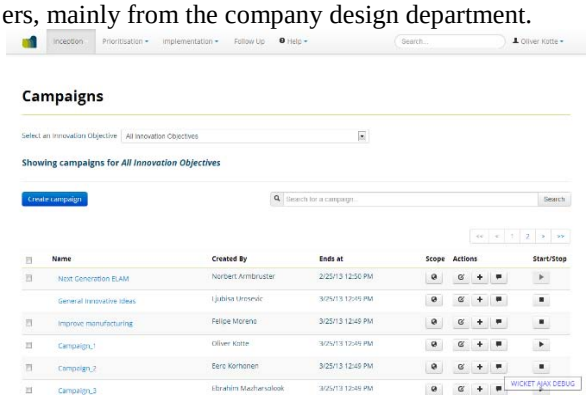

Figure 2: Definition of the Innovation Campaigns

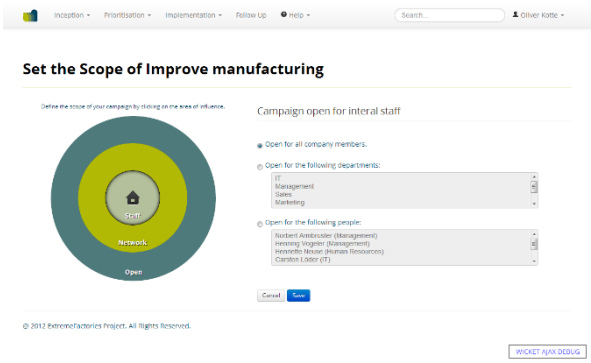

Figure 3: Setting the scope of a campaign

The ideas prioritisation services have (mainly) inputs from the Inception services. These inputs are in the idea prioritisation procedure pre-processed by the prioritisation services as a decision making support of the SME management. The platform provides functionalities to involve different roles in the review and approval of innovation projects' iterations, which are acting at different levels of the idea prioritisation.

For the ideas assessment, different supporting tools are implemented, such as Anonymous Voting, Prioritisation Matrix, Dot Voting and Simple form of Nominal Group Technique. It provides a systematic approach for idea evaluation and selection and involves a number of sub-phases. The realised functionalities guide decision makers through the selection process, ensuring informed decision making is undertaken.

At the technical level, the decision process is supported by external tools for product/process simulation, for virtual prototyping (of products), as well as with reasoning tools developed as a part of the platform. At the level of financial decisions, costs precalculation is performed, whereby the costs of all processes from design to the final project launch into the market, are taken into account. These factors will allow for the estimation of the idea's potential in the market place, its value and margin, the level of competition and its competitors, as well as, the companies' capabilities to develop the idea for the market.

All of these steps are providing inputs for the risk assessment, which assesses competition, technology, customers, economy, customer preferences, compliance of the new product with company's portfolio (current and possible portfolio widening), relation with proposed business models and other environmental factors. These tools are (mainly) interfaced to the platform as external applications in order to facilitate system development and optimise costs. Results of the ideas prioritisation are submitted to the SMEs management with corresponding output data for supporting decision making regarding the implementation, launching or cancelling.

The implementation supporting services are intended to enable a successful innovation project, starting from services for creation of a final design of the product/process to be innovated, based on the innovation "concept design" created in the ideas prioritisation phase. This "final design" is to be created by an external application and should be common for different company departments (e.g. planning department, shop floor, quality control, etc.). In addition the current prototype includes:

- Project planning/organisation, based on a set of example templates tools, enriched with agile approach based functionalities
- Creation of project schedule including key milestones list
- Creation of project financial plan
- Identification of key success factors

Along the implementation phase a business model, as one of the most important assumptions for a successful business process improvement, can be readapted to the commercialisation conditions and results; i.e. offering the possibility of reconsideration of the validity of the whole innovation.

Follow-up services use state-of-the-art methods to assess innovation after its implementation based on the market success and profit monitoring. These services provide inputs to an innovation repository, holding information about the whole procedures of all innovations, successful or not, carried out in a company. The whole process, from the basic idea to the final result, is stored, as well as the efficacy of the methods, techniques and tools used to implement the innovation.

2.4. Architecture

The developed platform is implemented as a SOA-based web application in a 3-tier architecture following the Model View Controller (MVC) pattern – as depicted in Figure 4 – consisting of the following layers:

Model Layer – enabling persistence of data and knowledge handled by the platform

Controller Layer – encapsulating the platform's business logic, and

View Layer – providing graphical user interfaces to the platform's users, both for PC-based browsers and mobile devices (i.e. smartphones)

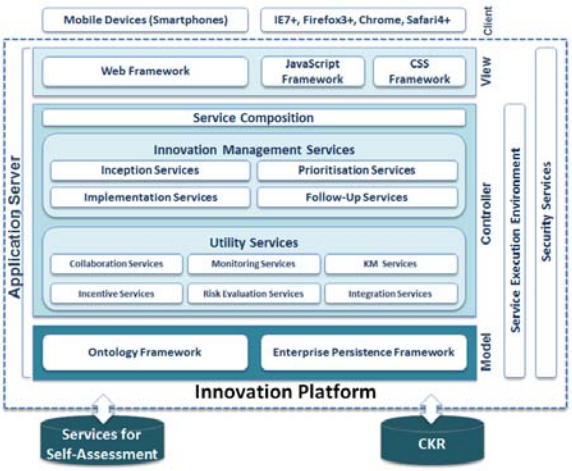

Figure 4: ExtremeFactories platform architecture

The Model Layer incorporates two components, the Enterprise Persistence Framework and the Ontology Framework. The Enterprise Persistence Framework is responsible for enabling the different services comprising the Service Layer to access different data stores; that is to perform Create, Read, Update and Delete (CRUD) operations on these data stores. The Enterprise Persistence Framework in this sense handles conversion of data from the data store specific format - in most cases this will be the relational model of a database (installation specific) - into the innovation platform's object model and vice-versa. This way, the different services can work on a unified object model abstraction and are able to transparently access different types of data stores. The Ontology Framework enables the services to perform CRUD operations and reason on ontology data by providing the same transformation from/to the unified object model abstraction as the Enterprise Persistence Framework.

The Service Layer is home to the two sets of services (Supporting Services and Innovation Management Services)that provide the General and Innovation Specific functionality as described above. These services are hosted in a service execution environment provided by the used application server and are exposing a RESTful API enabling external systems or different user interface implementations to utilise the platform provided functionality.

Finally, the View Layer provides the platform's user interfaces, currently realised in the form of HTML web pages tailored for common internet browsers. Certain platform functionality, upon request, can be also made available in user interfaces specifically adapted to smartphones.

2.5. Test Applications

Test application 1 was implemented in an SME dealing with development and manufacturing of weighing systems against specs and regulations. Many processes in this SME, including new product's development are done collaboratively, i.e. in an extended enterprise environment. One of the typical weighing systems consists of several modules, such as indicator (hard- and software), developed by sub-supplier A; controller – an embedded micro-controller provided by sub-supplier B, whereby the controller software is developed in this SME; a PC-based software tool to control the weighing system, developed by the SME; remote indication – display deployed outdoors next to a weighing system to visualise weighing data, also developed by sub-supplier A, and a PC-based software solution to visualise and analyse weighing data developed by SME.

Innovation process in this SME is usually triggered by observing new technologies and market trends as well as monitoring competitors' products and, in some cases, by requirements from federal authorities that issue the certificates for this SME's devices' application.

The here-described prototype of the innovation management platform was tested in the Innovation Inception phase using monitoring functionalities and functionality for prioritising innovative ideas, coming from demand-pull in the case of requirements from the certification authority.

Monitoring functionality was tested on a limited number of monitored sources, taking into account relatively low maturity of the developed prototype; the obtained results were generally satisfactory. It was discovered that mechanisms for adjustment of the precision of monitoring tasks definition require further refinement, which is related to the relatively limited scope of the ontology supporting this functionality.

For the prioritisation of the innovation ideas in the process triggered by the certification body, Case Based Reasoning functionality was tested. Obtained results were proportional to the number of previously solved cases stored in the CKR, which also allows for optimistic expectations regarding future applicability of the system.

Test application 2 was implemented in an SME dealing with development and manufacturing of systems for Monitoring and Control of Assembly Processes in manufacturing industry. This SME has a network of partners providing services such as Upfront-Service, suppliers of different hardware parts and devices, as well as sales and distribution partners.

The innovation triggers in this SME are standard customer requirements, i.e. demand-pull and technology-push. The third group of innovation triggers is so-called continuous innovation, i.e. causes coming from bug fixing and "weak points" removal.

Testing of the innovation management platform prototype was carried out using monitoring functionalities for internal monitoring of the number of reoccurring bugs and problems originating in products' "weak points".

Monitoring functionality was also tested on a limited number of reoccurring problems, with a corre-

spondingly low set-up warning threshold, which has shown appropriate functioning. This test was followed again with testing of the reasoning mechanism – CBR for suggestion of the most appropriate innovation ideas.

This functionality has shown the need for a changed approach in the selection of cases to base the reasoning mechanism on. Namely, not only similar solved cases are to be taken into account by the innovative ideas prioritisation, but also a new forecasting mechanism should be incorporated to take into account new technological solutions for reoccurring problems in order to keep pace with technology development and with competition. These results impose a need for further improvement of the monitoring functionality in terms of involvement of new technology sources monitoring into the suggestion of ideas for weak points removing.

4. CONCLUSIONS

The testing of applications at the relatively low mature prototype has shown results that indicate the directions for further development of the implemented mechanisms for decision support in the management of innovation process as a basic assumption for business process improvement. The relatively clearly indicated directions of further system improvements allow for optimistic expectations regarding future system applicability. It is obvious that the necessary efforts to complete the prototype are not low but the barriers are not impossible to overcome. One of the future research topics as it can be seen from test application 1, is the further investigation of additional reasoning capabilities of semantically related subjects, i.e. of precisely structured application specific ontologies.

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REFERENCES

[1] *Business Process Innovation through Open BPM*, http://www.bpm.com/business-process-innovation-through-open-bpm.html, last accessed December 2012

[2] ExtremeFactories Project FP7-ICT-2011-285164: *D1.4. System Concept, Public Report*, Project Consortium, URL: http://www.extremefactories.eu

[3] Urošević Lj., Reimer P., Kotte O., Elorriaga A., Lopez S., *Decision Support System for the Initial Phase of Innovation Process in Manufacturing SME*, Proceedings of International Conf. on Modern Information Technology in the Innovation Processes of Industrial Enterprises, MITIP 2012

[4] Majumdar A., Szigeti H., (2011), *ICT FOR MANUFACTURING, The ActionPlanT Vision for Manufacturing 2.0*, Report from the "ActionPlanT" project, http://www.actionplant-project.eu/

[5] Turner, S., *Business Process Improvement*, mThink, White Paper

[6] Herstatt, C.; Verworn, B. (2006), *The "Fuzzy Front End" of Innovation*, TU Hamburg, Harbourg, Working Paper, http://doku.b.tu-harburg.de/volltexte/2006/163/, last accessed May 2012.

[7] Bullinger, A. (2008): *Innovation and Ontologies*. Ph.D. thesis, Technische Universität München, Arcisstraße 21, 80333 München, Germany, DOI: 10.1007/978

[8] Tidd, J., (2006), *Innovation Models*, Discussion paper, Science and Technology Policy Research Unit University of Sussex, Imperial College London, http://www3.imperial.ac.uk/innovationstudies/publications/discussion_papers/innovation_models.pdf, last accessed April 2012

[9] Beales, R. M. (2004): *An Ontology-based Platform to support Organisational Innovation Networks*. Ph.D. thesis, School of Electronics and Computer Science, University of Sothampton, University Road, Sothempton, United Kingdom, http://eprints.soton.ac.uk/266401/, last accessed April 2012.

[10] Ning, K., O'Sullivan, D., Zhu, Q. and Decker, S. (2006): *Semantic innovation management across the extended enterprise*. International Journal of Industrial and Systems Engineering, Vol. 1, Number 1-2/2006, pp. 109–128, ISBN 1748-5045

[11] Riedl, C., May, N., Finzen, J., Stathel, S., Kaufman, V., Krcmar, H., (2009) *An Idea Ontology for Innovation Management.* International Journal on Semantic Web and Information Systems, 2009, Volume 5 Number 4, pp. 1-18.

[12] Koen, P., Bertels, H., (2010) *Front End of Innovation, kWiley* International Encyclopedia of Marketing, DOI: 10.1002/9781444316568.wiem05022

[13] Brunswicker, S., (2009), *The networked SME – Taking a closer look into open and collaborative innovation in European SMEs*, Open Innovation Speakers Series – Haas School of Business, UC Berkeley

[14] Sorli, M.; Stokic, D. (2009): *Innovating in Product/Process Development*, Springer, 1 ed., ISBN 978-1-84882-544-4, DOI: 10.1007/978-1-84882-545-1.

[15] Chidamber, S. R.; Kon, H. B. (1994): *A Research Retrospective of Innovation Inception and Success: The Technology-Push Demand-Pull Question*, International Journal of Technology Management 1994 - Vol. 9, No.1, pp. 94 – 112, DOI:10.1504/ IJTM.1994.02556

[16] Nemet, G.; (2009): *Demand-pull, technology-push, and government-led incentives for non-incremental technical change.* Research Policy 38 pp. 700–709, ELSEVIER, URL: http://www.journals.elsevier.com/research-policy, last accessed May 2012.

[17] Große Hovest, G., Grama, C., Urošević, Lj., Stokic, D., (2008) *Collaborative Environment for Virtual Collaborative Networks of SMEs*, Proceedings of 14th International Conf. on Concurrent Enterprising, ICE 2008, A new wave of Innovation in Collaborative Networks, pp. 79-86, Publisher CENTRE FOR CONCURRENT ENTERPRISES, ISBN 9780853582441

[i] http://bivee.eu