A Model Based Approach For Enterprise Innovation Management

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Abstract. In the paper at hand a model based approach for managing the knowledge based innovation aspects of an enterprise is presented. Meta modelling techniques are applied to design the organizational Knowledge Space and then the Knowledge Maturing Scorecards approach is applied to define, manage and visualize indicators concerned with innovation potential of established enterprise goals. Paper provides (1) overview on conceptual background of KMS and introduces a generic modelling framework to realise model based approach, (2) depicts the method for managing the indicators and (3) presents the web based prototype.

Keywords: Knowledge Space, Knowledge Maturing, Innovation Management, Meta Models, Balance Scorecard, Knowledge Management

1 Introduction

Survival and competitiveness of the enterprises nowadays are directly influenced by globalization, rapidly evolving markets and continuous changes in their customer's demands and requirements. Successful management of the enterprise assets on one hand and even more important ability to adjust to the fast-pace evolving situations (e.g. financial crisis, new competitors) – as we know it's not that the strongest and biggest survive but those that can adapt best – provides a winning combination to stay competitive. Although the aforementioned market-survival scenario can be successfully ported into almost any business related environment of last centuries, the fact that we live in the information era considers such specifics that the adaptation to the market – at least partly – equals to innovation and resources (assets) can be seen as knowledge applied for executing the core processes generating the value required to address the consumer (in the sense of Lean management) demands. This setting is quite complex as (1) innovation can be seen as everything but a strictly defined good or service and (2) knowledge within a company is in most cases available in an implicit or in an unstructured way – [1] argues that the percentage of unstructured knowledge within one company is as much as 80%. If we consider that, in an information-driven environment, knowledge available both within as well in the intermediate surrounding (e.g. inner supply chain) of the enterprise is directly responsible for generating the innovation it becomes obvious that techniques for managing such knowledge is almost a necessity for business survival. Even more, such techniques are seen as a vehicle to identify, externalize and structure, thus make knowledge available, as most of it is "hidden" within the company – e.g. known only to domain experts. This challenge was recognized decades ago, by both commercial as well as scientific communities and resulted over time in development of different knowledge management methods and tools including their deployment in different business/scientific settings. During the last two decades, as outlined in [2], authors have observed three phases describing such development/deplyoment: (1) Process Oriented Knowledge Management, (2) Service Oriented Knowledge Management and (3) Service Oriented Knowledge Provisioning – see [3], [4] and [5] for details. In the work presented in this paper methods and techniques from all three phases have been used to define knowledge, structure it and use it as measurement for innovation potential. Before defining and measuring the innovation indicators based on available knowledge and trying to measure them, one should focus on measuring and attaching value to the knowledge. Approaches toward such activity – known as intellectual capital monitoring focused on defining the ROK – return–on-knowledge – have been applied over time in different settings. Research carried out previously as outlined in [6] and [7], state that there is a strong link between intellectual capital and innovation capability of the enterprises, which goes inline with the approach presented here, but it fails to take into account the maturing dimension of knowledge, which can be applied to govern the innovation indicators.

As mentioned previously, before aligning the available intellectual capital with the innovation potential of the company, the first thing to do is the actuall structuring of the "accessible" knowledge. This is done by designing the so-called Knowledge Space, which is defined as "…the currently available knowledge concerning a specific domain or part thereof in a specific timeframe…" (see [8] for more details on Knowledge Space) and linking it to the so-called Knowledge Scorecard used to measure the intellectual capital of the enterprise (for details and an example of such a knowledge scorecard lacking the maturing perspective see [9]). In the next step the maturing indicators – providing information concerned with changes in the intellectual capital – are defined in order to provide an overview of the enterprise wide innovation potential – from the knowledge perspective.

This model driven and knowledge based approach is described in this paper as follows: after this introductory section, mapping the problem statement and research motivation, in the second section a model based method to transform the available and unstructured knowledge toward the presented Knowledge Space is depicted. Section three is in first part concerned with the concept of knowledge maturing and the mapping of the maturing indicators toward knowledge scorecard to depict the innovation aspects of an enterprise. The second part of third section covers the knowledge maturing scorecard prototype as an execution environment of the proposed approach, and in the last section a short conclusion as well as identified future challenges are presented.

2 Model Based Approach: The Knowledge Spaces

As outlined in the previous section, first step when moving as part of the organization's strategy towards a knowledge based process organization is the identification (discovery/finding relevant knowledge resources), structuring (defining the relevant knowledge processes) and finally designing the enterprise Knowledge Space. As described in [8], the Knowledge Space is comprised out of four dimensions: (1) the Form dimension of the Knowledge Space, which is concerned with the syntax and semantic, e.g. human experts, text documents, models, program code, mathematical formula or statistics, (2) the Content dimension, which is concerned with defining the actual domain (or part thereof) of the Knowledge Space, e.g. military knowledge in [9] or e-Government in [5], (3) the Interpretation dimension, which is concerned how Knowledge Space is interpreted, e.g. focused on machine based interpretation - in terms of Knowledge Engineering or on human based interpretation - in terms of Knowledge Management and (4) the Use dimension, which defines how the Knowledge Space is used, e.g. model processing. The process of designing the Knowledge Space is carried out by applying an appropriate knowledge management method. Selection of the method to be applied depends on the environment and involved stakeholders. Although more formal methods that are built around ontology based approaches may help to produce more "processable" Knowledge Spaces, they require involvement of knowledge engineers (as in [10]) and are not well accepted by the actual bearers of the knowledge – the domain experts when performing the task of designing the knowledge management processes. Involved stakeholders opt to apply tools allowing design of the Knowledge Space using graphical and process oriented modeling methods – vehicles they are more familiar with and likely to use in their everyday business. In the work presented here the generic modeling method framework from [11] has been applied to provide an additional benefit to the stakeholders, namely the framework enables amalgamation of different modeling methods allowing (1) stakeholders to keep their preferred language and (2) to combine it with concepts required to define the maturing indicators (as described in 3.1). Most prominent examples of such languages providing required functionalities that are both applied in commercial as well as in research projects include PROMOTE [12] and KDML [13]. PROMOTE was selected as knowledge modeling method to design the Knowledge Space and to define the Knowledge Maturing Scorecard. The selection was based on (1) a wider selection of modeling types which covered all relevant aspects required to define the Knowledge Space, as well as (2) ability to extend the modeling method with concepts from the Balance Scorecard approach (utilizing hybrid method development – see [14], [15] and [16] for details on this meta-model approach) using the meta-modeling platform in the back-end – ADOxx® [17] and applying the aforementioned generic modeling method framework. PROMOTE provides different model types that can be used to design specific dimensions of the Knowledge Space: e.g. Business Process models and Working Environment models , Knowledge Product model, Knowledge Management Process models as well as the Knowledge (Skill) Environment, etc. For more detailed description of the available model types, modeling procedures and sample scenarios see [18]. The Knowledge Resource model is for example used to identify and classify the knowledge resources directly connected with indicators defined in the Knowledge Maturing Scorecard and Knowledge Management process model is used to define the processes carrying out the innovation creation. Applying the knowledge management approach as depicted in this chapter results in a fully functional instance of the Knowledge Space. This instance is declared as so-called static Knowledge Space and can be extended for example by multi-agents (as applied in eHealthMonitor Project [19]) to realize dynamic Knowledge Spaces that can be extend on demand based on the current requirements imposed by the stakeholders (users of the Knowledge Space). In the following chapter the mapping between the knowledge processes and knowledge resources and so-called Knowledge Maturing Indicators as next step toward enabling Knowledge Maturing Scorecards is outlined

3 Knowledge Maturing Scorecard

In the following, first a brief overview on Maturing Indicators (as detailed in [20]) is provided, as well as their conceptual mapping toward Knowledge Maturing Scorecard, and then in the second part the prototype of Knowledge Maturing Scorecard is presented.

3.1 Maturing Knowledge as Innovation Indicator

As outlined in the introductory section, enterprises have to be able to adapt to the changes in their surrounding environment in order to stay competitive. One characteristics of this "adaptivity" is the amount of innovation generated by the enterprise. In the scope of this paper we focus on innovation generated through changes in the Knowledge Space of the company, and in special its the dynamic part, namely to the knowledge maturing and it's measurement. Knowledge maturing can be made explicit by following the Knowledge Maturing phase model (as depicted in [20]): (1) Expressing Ideas, (2) Appropriating Ideas, (3) Distributing in communities, (4) Formalizing, (5) Ad-Hoc Training, (6) Piloting, (7) Formal training, (8) Institutionalizing, (9) Standardizing and mapping it toward specific Knowledge Maturing Indicators [20] available within each phase. An example for such mapping, for an enterprise from educational/e-learning sector would be – "an individual is approached by others for help and advice" is mapped to a generic indicator within Knowledge Maturing Scorecard – "a person or an organization has been asked to share their knowledge" which is then mapped to a concrete instantiation of the Knowledge Maturing Scorecard for this enterprise – "number of invited talks" and measured over predefined periods. In order to measure and visualize the maturing of the innovation potential within the Knowledge Space, one has to take into account that the concept of knowledge maturing may have different meanings in different enterprises and scenarios, like maturing of the knowledge required to execute processes more efficiently, or maturing of the knowledge of the involved stakeholders so that they can react timely to market changes, etc. Therefore the indicators have to be kept general, and then specialized for each instantiation. The general concept of the Knowledge Maturing Scorecard aims at supporting the guidance towards the strategic position - innovation. According to the [21] the concept of the Knowledge Maturing Scorecard is derived from Balanced Scorecard [22] and is seen as an extension of the E-learning Scorecard [23]. The general concept of a scorecard can be seen as 1) communications channel, making the strategy of the enterprise transparent and thus improving its achievement, or 2) a performance measurement system and an instrument for strategic management.

Although based on the BSC approach, the main focus of the Knowledge Maturing Scorecard is definition and observation of the organization-specific goals (e.g. Innovation) for knowledge maturing within specific Knowledge Space. Main building blocks (in an e-learning/university context) of the Knowledge Maturing Scorecards are: (1) Perspectives – defining the viewpoint on the specific goals in the enterprise – may include e.g. People, (2) Strategic Goals – situated within a specific Perspective – for People perspective Strategic Goal would be Employee motivation, and (2) Indicators/Criterions – for Employee motivation would carry a concrete value. All perspectives, strategic goals and criterions are defined based on the context of the domain where KMS is applied. Graphical model of a KMS representing the aforementioned building blocks is depicted in Fig 1. On more formal level of description we can define the Knowledge Maturing Scorecard "KMS" through Perspectives "P" – defining the overall goals of the enterprise, Strategic Goals "SG" – defining the goals within one perspective, as well as Criterions "C" – defining the indicators on performance of a specific "SG". Therefore specific instance of KMS can be defined as $KMS_i = \{P_1, P_2 \ldots P_n\}$ where $P_{i1} = \{SG_1, SG_2 \ldots SG_n\}$ and $SG_{i1} = \{C_1, C_2 \ldots C_n\}$.

$C_{i,y,x}$ is defined by desired value "Y" and current value "X", e.g. $C_{i,5,2}$. Status "S" of the overall KMS_i which can be calculated by weighting the current statuses of P_i, SG_i and C_i respectively, may take one of the values $V_i = \{V_{red}, V_{green}, V_{yellow}\}$, whereas the weight "W" may be expressed in different units corresponding to the unit used to measure the P_i, SG_i and C_i. Additional aspect taken into account is the threshold factor "TF" which defines when the visual value of a strategic goal is reached– e.g. green – as shown on Fig 2. For KMS_i the $TF_i = \{TF_{td}, TF_{bu}, TF_{bs}\}$ defines the threshold direction that has to be reached for e.g. $C_i = V_{i,red}$. For selected threshold a value has to be defined. For example $TF_{td,1,2}$ reflects that $C_{i,9,10}$ would have $V_{i,green}$ although desired value of $C_{i,10,10}$ is not reached as threshold for "S" has been defined having $TF_{td,1,2}$ meaning that for $C_{ix} = 9$ and $C_{iy} = 10$ where X is current and Y is desired value, the $C_{i,x} = \{10,9\}$ -> $V_{i,green}$ and $C_{i,x} = \{8,7\}$ -> $V_{i,yellow}$ and for all $C_{i,x}$ where $x \leq 6$ -> $V_{i,red}$.

TF_i may influence V_i from top-down, bottom-up or both-sides. V_i for P_i, SG_i and C_i can be defined by calculating the current value. This can be done either without taking into account time aspect (e.g. trend, or different value sets for C_i) where the current value for SG_i would be:

$$SG_i = \frac{\sum_{k=1}^{n} Ci}{n}$$

and based on defined TF_i it will get a status V_i. Additionally one may adjust the values of C_i using W_i (extending the above formula) either over time or for specific objective for periods when C_i was elicited. Important is also to take into account how value of each C_i is calculated before calculating SG_i, as based on how the criterion is defined, positive values may be negative in overall context and vice versa (e.g. number of complaints). Next Section presents an overview on the realization of the KMS.

3.2 The Knowledge Maturing Scorecard: Realization Approach

As outlined in previous section, the Knowledge Maturing Scorecard can be seen as a conceptual tool for linking the business perspective (expressed as business goals which are of value to the organization) to knowledge maturing by using the

Knowledge Maturing Indicators in order to outline the Innovation potential of the enterprise. Fig. 1 provides an overview of graphical model (BSC based) used to conceptually define Knowledge Maturing Scorecard.

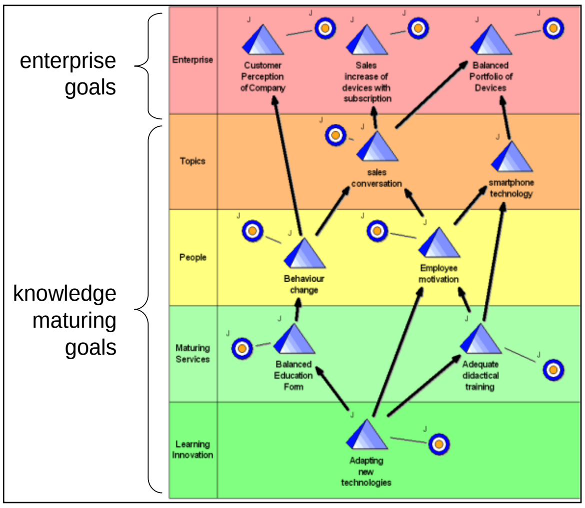

Fig. 1. Knowledge Maturing Scorecard Model

After the modeling of the Knowledge Maturing Scorecard instantiation (moving from general concept toward exact goals and set of applicable knowledge maturing indicators), the next step is continuous updating of the defined criterions for each strategic goal of the perspectives.

For this purpose a web based management component has been developed in order to allow both (1) manual update of the criterion values, as well as (2) periodical automatic update using web service interface. Fig. 2 provides an overview of web based components used to manage the deployed Knowledge Maturing Scorecard instantiation. As outlined in section 3.1 one of the goals of utilizing such a system is "...It is a communication means, making the strategy of the enterprise transparent and thus improving its achievement…". This requirement is tackled by the Knowledge Maturing Scorecard cockpit which provides a transparent and easy way of visualizing the current status of all KMS perspectives (and corresponding, strategic goals, indicators and criterions) and allows application of corrective measures (if applicable) to achieve the overall goal – successful managing of enterprise goals responsible for innovation. Knowledge Maturing Scorecard is realized using a SOA based approach. All components presented in this paper can be accessed and used online (web browser) and they offer API's to outside components using standardized web service interface.

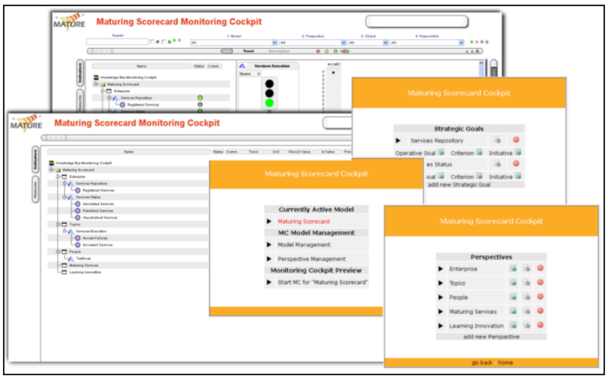

Fig. 2. Knowledge Maturing Scorecard Web Based Environment

4 Conclusion and Future Work

This paper provided a generic overview of how knowledge maturing can be applied to manage the innovation potential of an enterprise through application of a web-based KMS. This setting has been applied in different scenarios ranging from creating KMS for a University department, evaluating innovation potential of a large mobile provider as well as analyzing and tracking innovation of a Spanish e-Learning provider. Based on observations of these pilots and further research work we have identified points that are currently being addressed in two research projects, namely current focus is on (1) dynamic aspects of the Knowledge Space used as base for design of the KMS – employing multiagent systems to enable decision support on innovation based goals – as in [19] and (2) extending the innovation management capabilities of the system by connecting it to the Mission Control Room (MCR) platform developed in the BIVEE project (see [24] for details on MCR and [25] for details on the project).

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