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ON THE STRUCTURE MIRRORING APPROACH: FORESIGHT MODULE IN THE KNOWLEDGE MANAGEMENT SYSTEMS OF SMES

SPOGUĻSTRUKTŪRU PIEEJAS: FORSAITA MODULIS MVU ZINĀŠANU PĀRVALDĪBAS SISTĒMĀS

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Knowledge management, foresight, mapping, methods, tools

1. Introduction

In knowledge based society an innovative methodology used for future oriented thinking, research and management is foresight. Foresight aims at gathering anticipatory intelligence from wide range of knowledge sources in systemic way and linking it to particular decision making context, identified objectives and purposeful actions [1, 2]. Foresight process may be performed at different levels of scale, starting from one–person enterprises up to national and international companies/organizations .

Foresight can be seen as a kind of knowledge management (KM) aiming at futures and involving a set of planned sub-processes which may be performed using particular methods [3, 4]. A lot of these methods are known from other science and technology areas and they are currently used for many tasks in knowledge acquisition and processing – e.g., brainstorming,

structural analysis, Delphi survey, backcasting, priority setting, scenario building, etc. [1, 5, 6]. In foresight process, methods may be supported by appropriate information technology solutions and sound management.

The aim of this paper is to describe how foresight could become knowledge management systems (KMS) supported activity of small and medium enterprises (SMEs).

The paper is structured as follows. In Section 2 the related work and assumptions behind the solution are briefly described. Section 3 points to issues, which arise when foresight is to be supported in SME by KMS. Section 4 informs on solutions both handling the identified problems and introducing a module of SME's KMS for foresight activities. Section 5 consists of brief conclusions.

2. Related work and assumptions

The paper puts a foresight into the context of KM in an assumed situation: KM in a SME is supported by a KMS having particular modules (or services) for knowledge intensive processes such as quality management, strategic management, human resource management and others [7, 8, 9]. In such way, foresight is considered to be one of knowledge intensive processes supported by a KMS module of SME. In Fig. 1 a simplified conceptual model of a foresight module of SME's KMS is represented. A particular foresight process consists of a purposefully set of mutually interrelated sub-processes.

Lessons of 21 analyzed foresight exercises indicate that the sub-processes were quite similar in all foresight cases; however, the sequence of process steps differed [10]. Therefore the correspondence between foresight components and methods is considered in the conceptual model, but the correspondence between a particular foresight processes as a whole and the set of methods for performing this process is not considered.

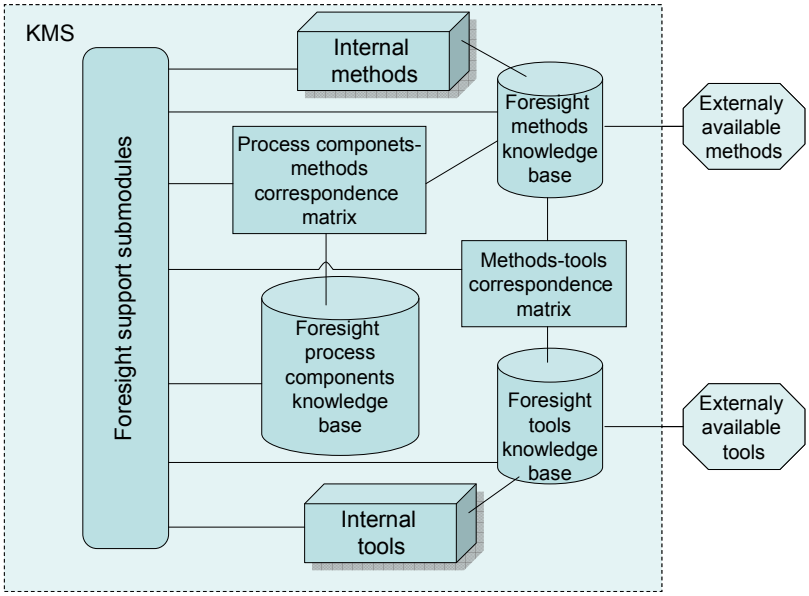

Figure 1. A simplified conceptual model of a foresight module for KMS of SMEs

In each foresight case particular methods are used that can be supported by appropriate KM software tools ("tools" in Fig. 1). The selection of methods and tools may be intuitive or

based on a priori knowledge (reflected in matrixes in Fig. 1) of correspondence between the foresight process components and methods and the methods and corresponding software tools available in the KMS or obtainable from external environment. It is essential that all knowledge bases (the knowledge base is seen here as a repository of explicit expert knowledge about foresight methods, tools and activities) may change when new knowledge is available. Likewise the contents of process components-methods and methods-components matrixes may be changed. The matrixes initially can be obtained using expert's judgment and later updated by utilizing new experts' knowledge and knowledge of executed foresight exercises.

From KMS viewpoint, the critical issue is to select and "run" the most feasible KM methods and tools in each foresight case. A foresight support module is similar to some extent to the information system because the module is based on information technology. Therefore, methods for evaluation of feasibility of information systems alternatives at early stages of design are applicable choosing the most appropriate support for foresight exercises [11]. However, not all criteria relevant for different types of information system are relevant for foresight support. It is necessary to select a subset of criteria that allow analyzing methods and tools feasibility exclusively for foresight process.

The selection of methods and tools for particular foresight components is non-trivial task, because many-to-many correspondence exists between the components and the methods and the methods and the tools. A similar task was already solved by structure mirroring approach (utilizing integrated top-down and bottom-up tool combination search) in selecting tool support for technical systems design in ASMOS system [12]. However in foresight case the situation is more complex because of availability of external methods and tools as well as dependence on other KMS modules that may use the same as well as different methods and tools as foresight module. The problems that arise in such situation are discussed in more detail in the next section, and solutions in terms of foresight support sub-modules are proposed in Section 4.

3. Problems to be solved by structure mirroring approach

Foresight process is not limited only by the choice of the approaches and methods and foresighting future. As any business process, it contains such activities as a establishment of a project team (foresight organization), theme choice, project management, recourses management and execution of foresight and foresight related processes. It is possible to indicate the group of methods and tools for each activity that are intended for foresight organization and implementation. There exist a lot of various methods, techniques, tools and approaches for foresight support from quite simple, informal approaches (e.g., conversation, strategic conversation) to methods based on statistical and mathematical analysis [1, 5, 6]. A list of the applicable methods and tools can be very long and choice may become a difficult task for SME with limited time and knowledge resources.

Several issues must be addressed dealing with structure mirroring approach in foresight context. Most of them are illustrated in Fig. 2:

- In foresight context the structure mirroring approach is based on the three level graph (Fig. 2a). The nodes of the graph represent foresight process decomposition on a top level, methods are represented by the nodes of the middle level and tools correspond to the nodes of a bottom level. By searching the graph from the top to bottom it is possible to form various combinations of methods and tools for foresight support.

During the search procedure it is necessary to minimize the number of possible combinations by casting aside non-feasible combinations and rank the feasible combinations according to their level of feasibility.

- The determination of the priority of the methods can be defined, using foresight methods classification (Fig. 2b). The methods could be classified depending on the input or output of the data type, performed tasks and the foresight time horizon. Other classifications also are possible, but it is necessary to take into account that the methods for foresight are very flexible and therefore usually form overlapping classes [1, 2, 5].
- In foresight exercise, methods may be used successively, in parallel or all simultaneously (Fig. 2c). This fact can influence the formation of the possible combinations, e.g., by use of some additional criteria while evaluating the methods combinations. On the other hand, this causes additional difficulties because of need to handle possible OR and AND linkages between process components and methods.
- It is possible to offer several alternative combinations of methods, which are obtained by structure mirroring approach. In that case it is necessary to create additional structures, which mirror the classification of methods and their relationships (see different shadings in Fig. 2b). When the basic list of the methods is created, bottom-up analysis is performed to determine, which alternatives are valid.

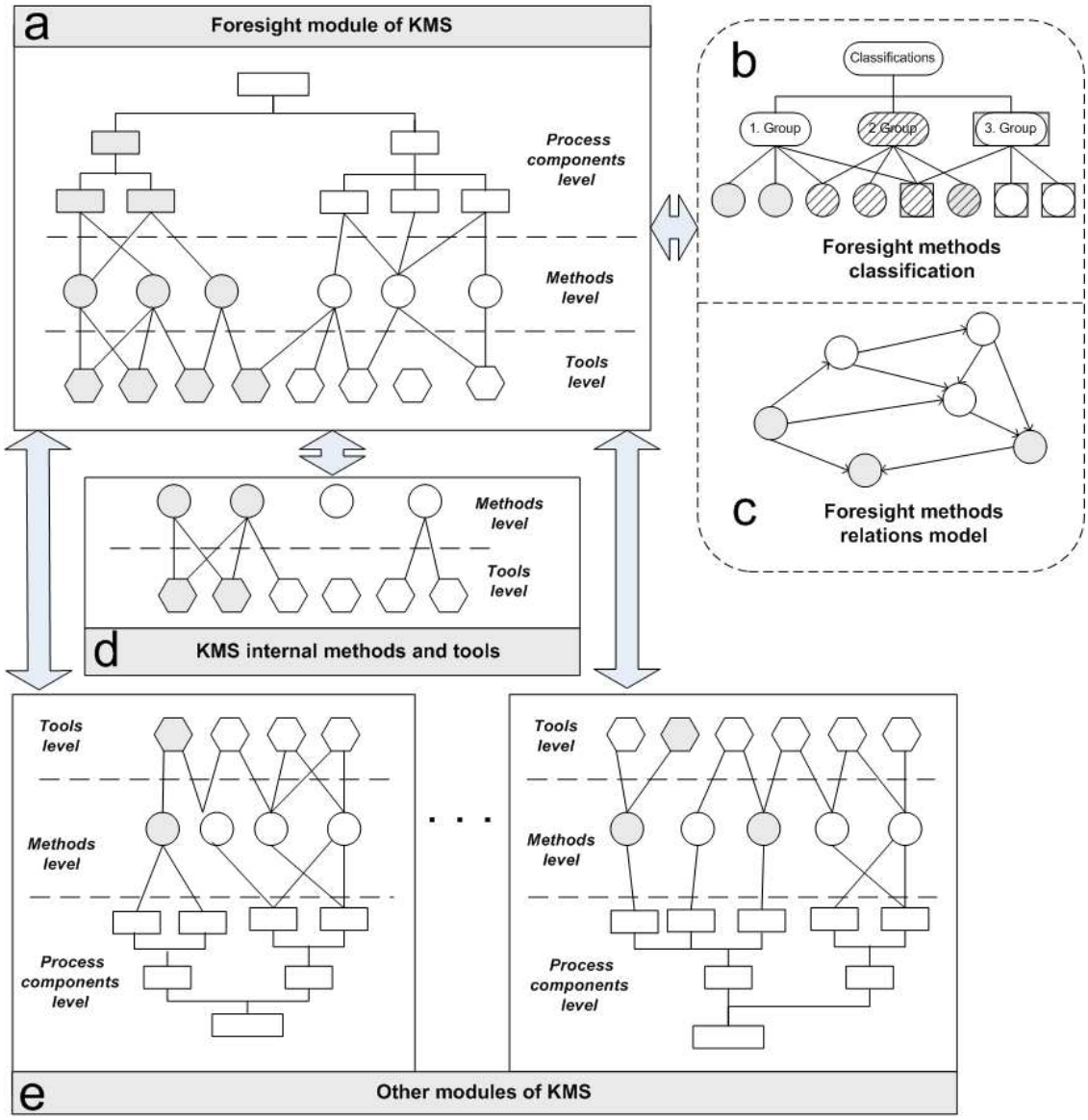

Figure 2. Structure mirroring approach: methods relations and classifications for identifying the scope of appropriate methods and tools

- There are different possible outputs and inputs of foresight tasks (foresight process components), but they are not taken into consideration the original structure mirroring approach, which considers only inputs and outputs of components compositions. Thus it is not clear whether the outputs of certain tasks coincided. It could be clarified by analyzing the links between the methods and exploring if the necessary outputs and inputs are provided. However, such approach is partly applicable because foresight activities include also manual work, and therefore outputs/inputs are not precisely defined.
- The organization has some known and used methods and tools, which are already integrated in KMS (Fig. 2d). Therefore it is necessary to differentiate between internal and external methods and tools in structure mirroring approach, e.g., by use of particular preference criteria with respect to the methods and tools that are the part of existing KMS infrastructure.

Above mentioned issues refer to identification of alternative combinations of methods and tools. In evaluation of those combinations the following aspects must be considered:

- The criteria for the choice of methods and tools should consider (a) internal infrastructure of KMS (b) functional difference of the tools (support of foresight organization or implementation); (c) SME's knowledge on usage of particular methods and tools, etc.
- Top-down and bottom-up search could be guided by tools installation and running requirements and costs of software use or other parameters.
- It would be advisable to analyze whether the generated combination of methods and tools coincide, and whether it is applicable in terms of SME's knowledge, technical and financial resources. For instance the cheapest *Open code* technique could be not the best decision, because of lack of appropriate programming knowledge resources in the enterprise.

There are some other aspects, which could be taken into consideration in implementation of structure mirroring approach:

- It is important for SMEs to execute tasks in the shortest period of time. That means that the estimated length of learning period is to be taken into account for external methods and tools.
- Foresight process is a part of organizational knowledge management, which includes other knowledge management processes: strategy formulation, human resources development, etc. (Fig. 2e). For each of these processes it is possible to create similar KMS support modules. Each module leans on its own structure mirroring approach and choice of the criteria. Methods and tools may be shared by the modules therefore dependencies of the modules is another issue relevant in foresight module introduction and maintenance.
- In course of time it is possible to complement the foresight process modules with new methods and support programs, so there should be a mechanism, which would help to develop and extend the primary structure mirroring and its criteria.
- The non-specific methods and tools such as project management, book-keeping, resource management are to be taken into account in generating infrastructure combinations for foresight support.

4. Towards the foresight module in the SME's KMS

The purpose of the module is to support SMEs in finding and using appropriate methods and tools for the certain foresight tasks. A search of the most feasible solution is based on structure mirroring approach. The approach utilizes the graph G = (V, E), where V – *graph's node set* (V={action$_1$,..., action$_n$, method $_1$,..., method$_k$, tool$_1$,...,tool$_r$}, $V \neq \varnothing$) and $E \subseteq V \times V$ - *graph's links set* showing the correspondence between different types of nodes. It is possible to assign the weight to each node according to particular search criteria if such are defined.

The KMS module for foresight support includes several sub-modules: (1) *the sub-module of scanning* allows to determine all the used methods and tools in different knowledge management processes. 2) *the searching sub-module's* purpose is to define a combination of tools for a certain foresight task. 3) *the updating sub-module* is meant for the maintenance of foresight sub-module of KMS, 4) the *actualisation sub-module* helps to share foresight module' knowledge among other modules of KMS . The first two sub-modules are discussed in more detail in Subsection 4.1 and 4.2 accordingly.

4.1. Scanning sub-module

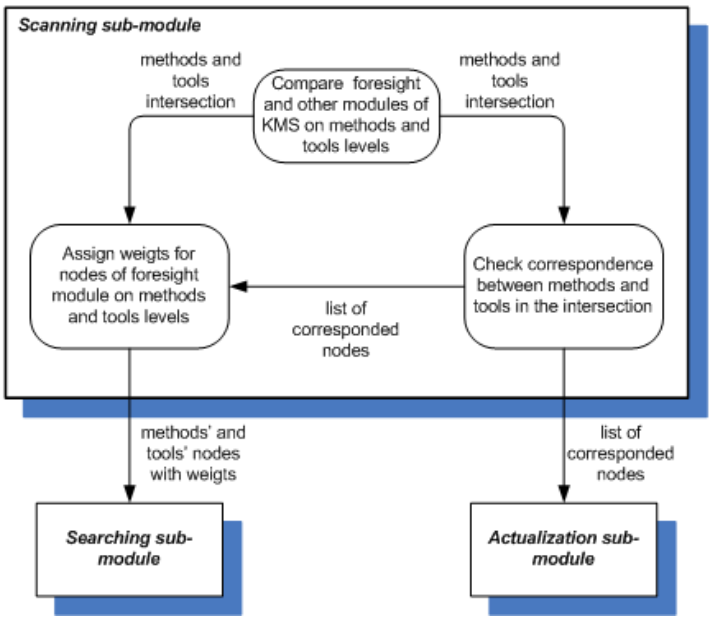

Figure 3. A simplified process model of scanning sub-module

Scanning sub-module performs the following tasks (Fig. 3):

- The purpose of the sub-module is to determine methods and tools, which are used not only in foresight tasks, because they may have a higher priority for the SME, taking into consideration that structure mirroring approach could be also applied to other KMS modules. That is why there is a possibility to compare foresight modules and other module's graphs one by one. Thus, the intersection of the methods and tools can be obtained.
- From the obtained intersection using the "weight" function $V \to R$, which assigns a corresponding "weight" to particular nodes, it is possible to select needed methods and tools.
- In addition, it is suggested to check correspondence between methods and tools in the intersection of foresight and other KMS modules. On the one hand it gives a possibility to increase weight of nodes in the foresight module; on the other hand gives an opportunity to update foresight module's mirroring structures with new links. However this step is optional and may be performed on user request.
- As the result a weighted graph is produced, which actually integrates foresight module into KMS.

4.2. Searching sub-module

Searching sub-module performs the following tasks (Fig. 4):

- It is possible to use knowledge base received from previous iterations or to work with initial knowledge base in the beginning of the searching. In latter case is necessary to adapt general foresight module structure mirroring to a particular user, by determining the criteria, which will be used for assigning weights to the graph nodes. Users need to

give information about existing KMS and IT environment in his organization, as well as to determine foresight exercises and process components. User's questionnaire is used for getting the information. The user should answer the following questions:

- Which methods and tools have already been used in the enterprise?
- What are the technical requirements for tools: platform, programming language, the necessary resources etc.?
- Is it necessary to consider time for learning and applying particular methods and tools?

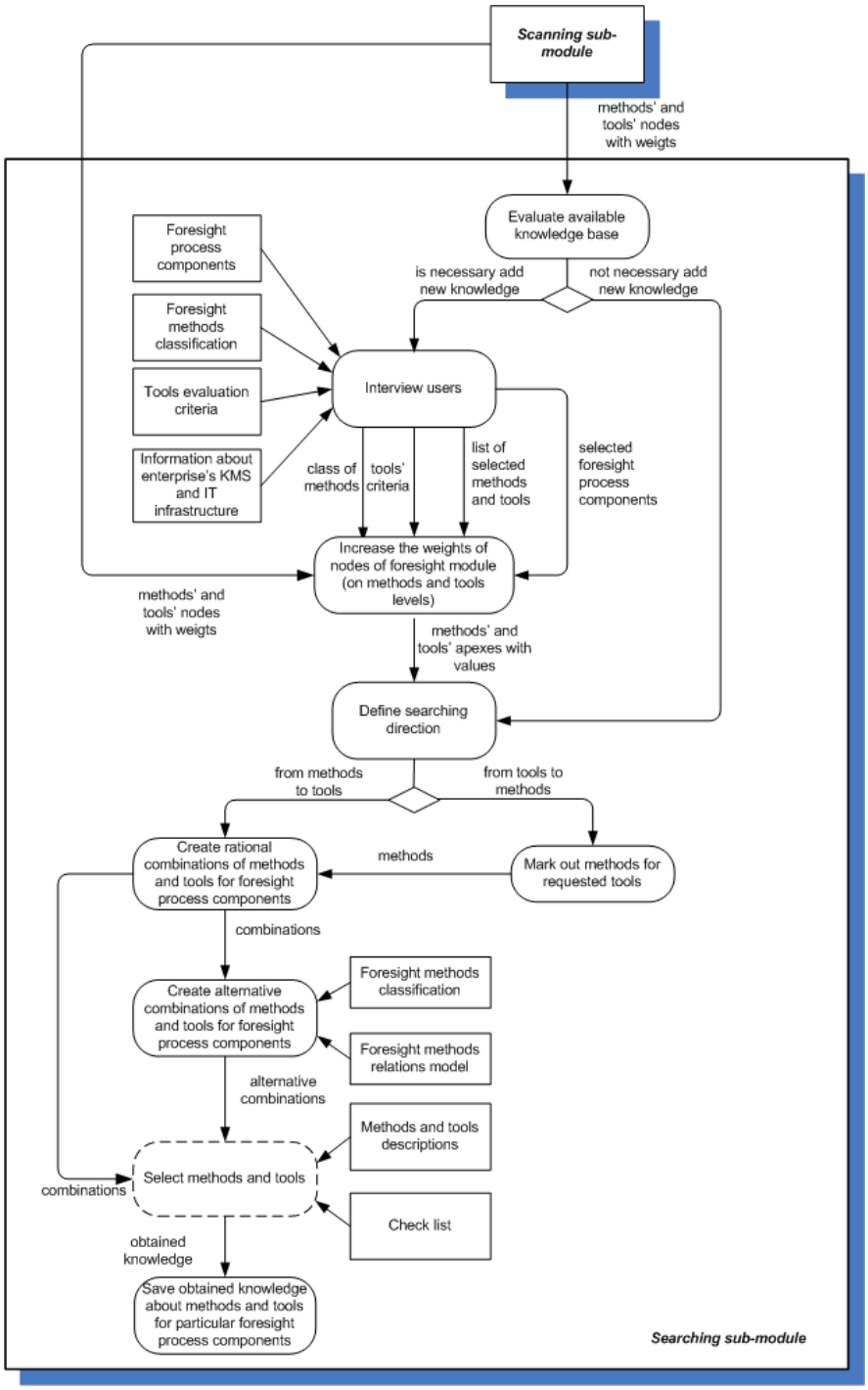

Figure 4. A simplified process model of searching sub-module

- What is the limit of tools' price?
- Is it necessary to define priority for tools, supporting a number of several foresight methods?
- Is it necessary to define priority for tools whose developers are known and their software products have been already used?

Requirements for methods could be specified additionally to questions. Different foresight methods classifications are used for requirements specification [1, 2, 5, 13]. Possible questions for eliciting requirements through methods classifications are given in Tab. 1.

Table 1. The fragment of method classifications based questions

Methods classification	Questions
Methods' classification depending on kind of output	
Diagnose	Is it necessary to understand existing situation?
Prognoses	Is it necessary to predict future?
Prescription	Is it necessary to define what should be done?
Quantitative	Is it necessary to characterize research by quantitative measures?
Qualitative	Is it necessary to characterize research by qualitative measures?
Normative	Is it necessary to start with examination of future condition and then define how to archive it and is it achievable?
Exploratory	Is it necessary to start with current condition and move to the future taking into account explored tendency in the past
Predictive	Is it necessary to use structured approach?
Open	Is it better to use creative or non-formal approaches?
Methods' classification depending on kind of input	
Expert-based	Is it necessary to propose methods based on experts' viewpoints?
Assumption-based	Is it necessary to propose methods based on assumptions?
Statistical or mathematical analysis - based	Is it necessary to propose methods based on statistical or mathematical analysis?
Methods' classification depending on foresight process	
Identifying issues	Is it necessary to propose methods acceptable for initiation of foresight process due to the fact that it could be helpful to define tendencies and directions as a basis for foresight processes?
Extrapolative Approaches	Is it necessary to propose statistical methods based on strictly defined assumptions?
Creative Approaches	Is it necessary to propose methods providing good visualization?
Prioritization	Is it necessary to propose methods for defining priority for technology development or research?
Methods' classification depending on time horizon	
Foreseeing	Is it necessary to propose methods acceptable for predicting future and getting knowledge before event accrue?
Managing	Is it necessary to propose methods emphasizing "acting today taking into account future's vision" ?
Creating	Is it necessary to propose methods emphasizing "future doesn't exist and could be created" ?
Methods' classification depending on workgroup	
Information inputs for groups	Is it necessary to propose methods providing workgroup with information?
Working group methods	Is it necessary to propose methods for workgroups?

- The results of the questionnaire are used to increase weight of foresight module graph's nodes (on methods and tools levels) with "weight" function $V \to R$. It allows finding feasible combinations of methods and tools faster, by giving preference in combinations list to those combinations, which have higher overall weight.
- It is possible to start the search in two directions: from the methods to the tools and vice versa:
    - *from methods to the tools*: Graph theory methods are applied for graph's exploring taking into consideration the existing weights of nodes. As a result several methods and /or tools combinations may be found.
    - *from tools to the methods*: First of all it is necessary to mark out the methods corresponding to required tools and then implement steps of searching from tools to the methods.
- It's possible to produce the alternative scope of methods and tools if none of the suggested combinations suit the user. In this case foresight methods classifications and methods relations model could be used. It may be achieved by looking through the methods from the primary list and defining which methods are included in the same group, or which methods provide the same inputs and outputs.
- Tools descriptions and check lists could be used in order to simplify the choice of appropriate methods and tools from various combinations. This tools description includes the characteristic of different features, such as cost, platform, programming language, the necessary technical requirements. The check lists may include questions from the questionnaire based on LIETIS approach [11]. Tab. 2 represents a fragment of information systems evaluation factors included in LIETIS system and useful for foresight module development. Those evaluation factors could be specified and expended. Similar descriptions and check list can be developed for selections of relevant methods.
- The information about the users' choice and knowledge about obtained weights of nodes (on methods and tools levels) should be saved for the purpose of defining weight of nodes more preciously in the future. This knowledge is saved in the Foresight methods knowledge base and Foresight tools knowledge base (Fig.1).

Simplified description of performance of foresight module's sub-models give an insight on the way how structure mirroring approach can be applied for the task of selection of methods and tools for foresight needs. In very simple cases this method can be substituted by direct use of experts' knowledge on methods and tools or by minimizing the search space up to few methods and tools.

4.3. Further development of the foresight module concept

The foresight module description given in Section 2 and Sections 4.1 and 4.2 of the paper forms the basis for foresight module implementation in KMS of SMEs. However not all solutions for problems described in Section 3 are provided by models presented in Section 4. Therefore there is an opportunity to extend the capabilities of foresight module by adding the following new sub-modules:

- A sub-module for integration of foresight module with methods and tools for project management, bookkeeping, resource management and other general enterprise tasks
- A methods inter-connection criteria based alternative methods and tools combinations evaluation sub-module

- A methods inputs and outputs analysis module for ensuring methods inter-connectedness

Table 2. The fragment of evaluation factors for information systems LIETIS approach [11]

Evaluation factors	Questions
IS maintenance costs	IS (Software, IT infrastructure) maintenance price per year
	Expenses related to employees involved in IS support per year
Costs of implementing new features in existing IS	Implementation of functional features in IS
	Expenses related to implementation of technical changes in infrastructure
	Expenses related to increase of number of IS users (costs per on user)
IS functionality	Does user interface support language suitable for enterprise?
	Is it possible to adopt user interface?
	Is user interface known and suitable for users?
	Is help supported in IS?
	Is help supported in IS on language suitable for enterprise?
IS technical usefulness	Is it possible to add new users for technical solution to be implemented?
	Is it possible to join new technical support solutions with newest solutions could be actual in future?
IS usefulness and influence on enterprise's goals	Is IS corresponding with enterprise's goals?
	Is IS functionality corresponding to the enterprise's goals achieving strategy?
IS usefulness and influence on enterprise's structure	Is IS able to operate within existing enterprise's structure?
	Is IS able to support existing or planned structure of data flow?
IS usefulness and influence on enterprise's business processes	Does IS functionality support business processes?
	Dose IS support data flows needed for particular business processes?
	Is IS able to support sequence of existing or planned business processes within the enterprise?

Another opportunity resides with the possibility that foresight module may be shared by several enterprises. For instance, it may be implemented in the KMS of Riga Technical University (Fig. 5).

Availability of foresight module at the higher educational institution gives an opportunity to keep the foresight module knowledge bases in up-to-date state, as well as to serve SMEs by offering consulting services, shared databases and shared foresight module for running foresight exercises or establishing individual foresight module into enterprise KMS according to particular needs of each SME interested in utilization of foresight in its future oriented activities.

Conclusions

The paper discusses problems, which arise in dynamic definition and maintenance of methods and tools for KMS supported foresight in SMEs. It proposes a solution of part of the problems by use of structure mirroring approach, which utilizes integrated top-down and bottom-up search in the space of foresight process components, methods and tools.

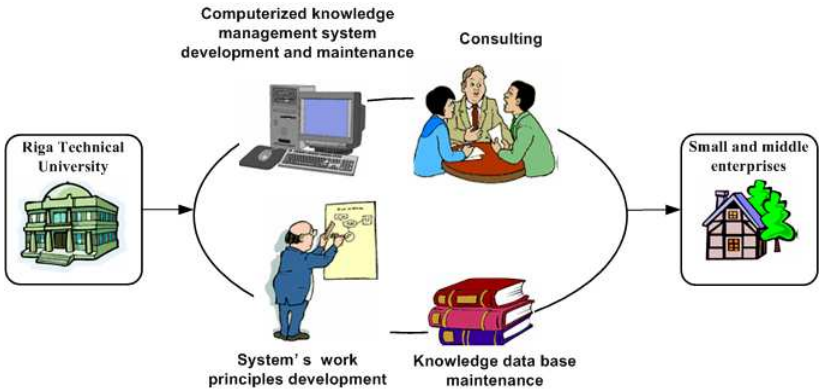

Figure 5. Riga Technical University as a consultation base for SMEs

However, not all possibilities of intelligent method selection are utilized in the approach, for instance, (1) disjunction (logical OR) and conjunctions (logical AND) connections between foresight activities and methods are not considered in this paper, (2) correspondence between foresight activities outputs and inputs is not taken into consideration, (3) inter-connections between foresight exercise methods (methods may be used successively, in parallel or all simultaneously) are not utilized. Therefore approach gives an opportunity to select a feasible methods and tools collection for particular foresight exercise, but do not provide means for selecting the most feasible collection among the feasible ones. Additional research is needed to combine appropriate activities decompositions and foresight activities and methods inputs and outputs analysis to obtain more formal means for selecting the most feasible collection.

The practical experiments with foresight module definition let to assume that similar approach may be applied for definition and maintenance of other KMS modules, which support knowledge intensive processes that have abundance of available methods and tools for manual and automatic execution of their components.

Acknowledgment

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Bušinska L., Stecjuka J., Kirikova M. Spoguļstruktūras pieeja: forsaita modulis MVU zināšanu pārvaldības sistēmā.

Forsaits ir intensīvais zināšanu iegūšanas process, kura mērķis izveidot uzņēmuma iespējamas konceptuālās "nākotnes". Šādas "nākotnes" var tikt analizētās ar nolūku pieņemt labi informēto stratēģisko lēmumu ar pārliecību, ka šīs stratēģijas tiks savlaicīgi atbalstītas ar piemērotiem IT risinājumiem. Rakstā forsaits tiek apspriests zināšanu pārvaldības sistēmas kontekstā maziem un vidējiem uzņēmumiem, īpaši ņemot vērā IT nodrošinājumu nepieciešamo forsaita organizēšanai un izpildei. Zinātniskajos darbos ir piedāvāts daudz dažādu metožu, tehniku un pieeju, kas ir izmantojami zināšanu pārvaldības aktivitāšu izpildei, tai skaitā arī forsaitam. Turklāt ir izstrādāta virkne IT risinājumu, kas atbalsta vienu vai vairākas metodes. Tādējādi piemeklēt optimālo IT risinājumu kopu nav triviālais uzdevums. It īpaši tas ir aktuāls maziem un vidējiem uzņēmumiem ar ierobežotām iespējām. Piemērota atbalsta sistēma un vadlīnijas varētu palīdzēt izvēlēties racionālu metožu un IT risinājumu kombināciju noteikta uzdevuma risināšanai, ņemot vērā organizācijas vispārējo zināšanu pārvaldības infrastruktūru. Piedāvātais risinājums paredz forsaita moduļa izstrādi kā daļu no uzņēmuma datorizētas zināšanu pārvaldības sistēmas. Moduļa mērķis ir racionālā risinājuma meklēšana, balstoties uz spoguļstruktūras pieeju, kas ļauj specificēt atbilstību starp forsaita aktivitātēm, metodēm un IT risinājumiem, savukārt, Grafu teorijas pieejas izmantošana palīdz veidot iespējamās kombinācijas un noteikt to prioritātes.

Businska L., Stecjuka J., Kirikova M. On the Structure Mirroring Approach: Foresight Module in the Knowledge Management Systems for SMEs

Foresight is a knowledge intensive process aimed at creating possible conceptual „futures" of particular enterprises. Such „futures" may be analyzed with the purpose to make well informed strategic decision and assure that these strategies are timely supported by appropriate IT solutions. In the paper the foresight will be discussed in the context of knowledge management system of small and medium enterprises, especially taking into consideration the IT support needed for the foresight. In knowledge based society a huge amount of methods, techniques and approaches are currently suggested and used for many knowledge management tasks, including foresight. More over, a lot of various IT solutions are suggested for supporting one particular method or several methods simultaneously. Therefore, the selection of the scope of appropriate methods and IT support

techniques is a non-trivial task, - especially for small and medium enterprises with limited time and knowledge resources. Appropriate support system and guidelines could help to choose the methods and IT solutions for foresight exercise, taking into consideration overall organizational knowledge management infrastructure. The solution discussed in the paper suggests use of the foresight module as the part of the computerized knowledge management system of the enterprise. The purpose of the module is to support small and medium enterprises in selection of feasible methods and tools combination for their foresight exercises. A structure mirroring approach is used to identify the correspondence between foresight tasks, methods and IT solutions, Graph theory methods are applied for finding and prioritizing feasible combinations of methods and tools.

Бушинска Л., Стецюк Ю., Кирикова М. Подход структуры зеркального отражения: модуль форсайта в системе управления знаниями МСП

Форсайт это интенсивный процесс познаний, цель которого – создать возможное коцептуальное «будущее» предприятия. Такое «будущее» возможно анализировать с целью принять хорошо информированное статегическое решение, будучи уверенным, что выбранная стратегия своевременно будет поддержана подходящим ИТ-решением. В статье форсайт рассматривается в контексте системы управления знаниями для малых и средних предприятий, беря во внимание ИТ-обеспечение, необходимое для выполнения форсайта. В научных работах рассмотрено множество различных методов, техник и подходов, которые возможно применить для реализации процесов управления знаниями, в том числе и форсфйта. К тому же разработаны ИТ-решения поддерживающие один или несколько методов. Таким образом подобрать оптимальный набор ИТ-обеспечений является нетривиальной задачей. Особенно это актуально для малых и средних предприятий с ограниченними ресурсами. Соответствующая система поддержки и рекомендации могли бы помочь в подборе рационального набора методов и ИТ-обеспечений для решения определенной задачи, беря во внимание инфраструктуру системы управления знаниями организации. Предложенное решение предусматривает разработку модуля форсайта как часть компюторной системы управления знаниями предприятия. Цель модуля – поиск рационального решения, основываясь на использовании подхода структуры зеркального отображения, который позволяет специфицировать соответствие между процесами форсайта, методами и ИТ-обеспнчением, в свою очередь подход Теории графов используется для формирования и ранжирования возможних комбинаций.