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Contents

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Framework development for dynamic early warning and proactive control systems in food supply chain networks

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Keywords: framework, early warning, proactive control, model and knowledge based DSS, expert system, ontology

Food supply chain networks (FSN) are currently confronted with a lot of challenges that call for innovation and change. They have to cope with:

- Expanding and more open international markets with increasing competition thus calling for cost leadership and appropriate and versatile market propositions in terms of products and services.
- Ever more demanding customers. Customers with unpredictable demand and wishes with respect to products, their properties (think about animal friendliness, etc), services and transparency with integrity.
- Retailers and NGO's that impose more and more requirements and constraints and who claim to voice the wishes and demands of customers.
- Increased legal demands and requirements.
- New technologies that 'call' to be used since these technologies enable cost leadership, increased and guaranteed quality levels and more rapidly changing product and service assortments (time to market improvements).
- Increased vulnerability in case of food problems and calamities with associated liabilities and risks.

These encompass direct risks in financial terms and risks to lose the confidence of the business partner and customer that in turn also translate into financial risks. This vulnerability is even aggravated by increased transparency. Food problems are published in our media, almost on a daily bases. These problems can jeopardize the very existence of products on the market and of the companies producing them. The nature of these problems may have to do with various aspects, such as food quality, operations, or logistics. For example, chickens may die before they arrive at the slaughter house and or have quality attributes that are not in compliance with requirements defined for quality slaughtered products. A similar situation with respect to quality deviations may exist in pork chains. The weight and quality of pigs arriving at a slaughter house may not satisfy defined requirements. For example the bacon quality of the pigs is of great importance if you want to produce for the British market. Similarly pigs have to satisfy very particular quality requirements for products to be delivered to Japan. Further products may not have the right quality, or even be contaminated with (toxic) substances. These problems thus cause potential

losses to the food industry and may cause that the trust in the food system decreases. In order to reduce these losses, it is necessary to predict potential problems in FSN as early as possible and thereafter to take proactive actions to prevent those problems or correct their effects. However, specific characteristics of FSN make it difficult to find out causes and take corrective action in time when problems occur, especially when domain knowledge is missing. Fortunately, during the last years we have seen the rapid development and use of operational information systems (OIS) in FSN that provides us with opportunities to find valuable information about performances from recorded operational data.

In our research, we are aiming at building early warning and proactive control systems in FSN that are based on the information contained in the mentioned OIS in order to effectively and efficiently avoid and control problems in FSN. They aim to enable managers to exploit recorded data by employing various Data Mining (DM) methods to find causes of problems and predict potential problems based on the status of current FSN. It also collects knowledge obtained in real cases into a knowledge base for managers' reference. In this paper, we present a framework for dynamic early warning and proactive control systems in FSN.

This framework is built upon our experience in dealing with decision support problems in real cases and on reported developments and experiences in literature. It contains knowledge on both content and process aspects for applying DM methods to deal with problems in FSN. We provide a process model to illustrate the processes for managers to utilize this framework. This process model takes manager's resources into consideration. It helps managers to take advantage of their knowledge and resources while using this framework. For each step of those processes, we also provide information on prerequisites, outcomes, and evaluation criteria in order to ensure that managers arrive at appropriate and usable solutions.

The framework consists of the following components: user interface, knowledge base (in which we find a database and model container and an ontology), task classifier and template approaches, DM method library and ES for method selection, and an explorer/ predictor. The knowledge base is designed to incorporate the knowledge about existing problems in FSN together with their causes, and utilized DM methods. This knowledge base provides essential knowledge sources for managers to deal with real problems in FSN. Managers can either browse the knowledge base for causes of problems or use appropriate Data Mining methods to analyze collected data for causal factors. After that, they can predict potential problems and take timely actions to prevent losses. Since some of those steps require managers to apply specific knowledge on Data Mining, we provide multiple template approaches to guide managers through these steps. For example, in order to use prediction, a manager has to find proper methods, set proper parameters, interpret outcomes of algorithms, and fine-tune settings in order to get optimal results. Template approaches for prediction are needed here to serve as guidelines for managers executing these steps.

More detailed explanations of each component are given in our presentation, together with important relations between them, how managers cooperate together with them for early warning and proactive control of problems in FSN. Detailed explanations about our approach and framework for Dynamic Early Warning and Proactive Contrtol Systems can be found in [1].

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An extension of Data Envelopment Analysis using an interactive Tri-criteria Linear Programming package (TRIMAP)

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Data Envelopment Analysis (DEA) measures the relative efficiency of comparable entities called Decision Making Units (DMU's). Li and Reeves (1999) presented a tri-objective model in order to solve two of the major concerns related to DEA, namely, increasing the DMU's discrimination and looking for a better distribution of the multipliers. The authors suggest the extension of the CCR model (Charnes et al, 1978), considering two extra objective functions, i.e. a min-max function, corresponding to a measure of equity and a min-sum function, favouring some sort of overall evaluation of the DMU's, from the point of view of the DMU under analysis. Furthermore, TRIMAP is a tri-criteria linear programming interactive package dedicated to a progressive and selective learning of the non-dominated solutions (Climaco and Antunes 1987, 1989). The graphic decomposition of the weighting space (used in TRIMAP as an operational tool rather than to elicit preferences of the decision makers), the possibility of introducing constraints on the objective function values during the search automatically translated into the weighting space, as well as other interactive tools available in TRIMAP, make it specially adequate to explore, in a broader and more effective sense, the model proposed by Li and Reeves. Furthermore, we introduce a new evaluation index in the framework of the above referred to model. Finally, a case regarding five privatized Brazilian highways is presented and discussed, emphasising the potentialities of TRIMAP in the interactive analysis of the problem.

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Learning ensemble of decision rules for ordinal classification

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Keywords: ordinal classification, ensemble methods, decision rules, boosting, forward stagewise additive modeling

In the prediction problem, the aim is to predict the unknown value of an attribute y (also called *decision attribute, output* or *dependent variable*) of an object using known joint values of other attributes (also called *condition attributes, predictors*, or *independent variables*) $\mathbf{x} = (x_1, x_2, \ldots, x_n)$. In the *ordinal classification*, it is assumed that $y = \{r_1, \ldots, r_K\}$, where r_k, $k = 1, \ldots, K$, are K distinct and ordered class labels $r_K \succ r_{K-1} \succ \ldots \succ r_1$, where $\succ$ denotes the ordering relation between labels. This problem shares some characteristics of multi-class classification and regression. A value set of y is finite, but in contrast to the multi-class classification, the order between class labels can not be neglected. The values of y are ordered, but in contrast to regression, the scale of y is not cardinal.

In many applications, for example, in recommender systems, users are often asked to evaluate items, by using a finite set of possible labels ranging from "1" to "5" (see, for example, Netflix Prize problem [5]). These labels are discrete, and there is a finite number of them, so they are like class labels in classification, but they are ordered — an evaluation of "3" is better than "2" and worse than "4". As another application, let us consider, the problem of email classification to groups like: "very important", "important", "normal", and "later". Here, we have also an order among groups labels, because an email labeled as "normal" can be read after "important" emails, but before "later" emails.

Nevertheless the problem of ordinal classification is often solved by multi-class classification or regression methods. In recent years, however, some new approaches tailored for ordinal classification were introduced [4, 1, 2, 7, 6]. In this paper, we take first a closer look at the nature of ordinal classification. After this we introduce a novel ensemble learning algorithm based on gradient descent approach, where the base classifiers are simple decision rules. The learning is performed by greedy minimization of, so called, threshold loss [6] using a forward stagewise additive modeling [3]. Experimental results are given that demonstrate the usefulness of the approach.

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On framework for exploring market scenarios in convergence of telecommunications and broadcasting

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Keywords: scenario, telecommunication and braodcasting market, agent model

Digital television is a telecommunication system for broadcasting and receiving moving pictures and sounds by digital signals, in contrast to conventional analog television system. Many countries are going to switch from analog television to digital television systems. The switch does not only imply business opportunities for television appliance manufacturers and broadcasting facility makers, but also provides opportunities for telecommunication carriers and internet providers. This is because advanced digital technology permits the telecommunication lines to be used for telecommunication services as well as for broadcasting services. This phenomenon is so called convergence of telecommunications and broadcasting.

In the past, business players in providing moving pictures and sound business are limited to content holders/producers, broadcasting service providers, packaged media distributors, appliance manufacturers, and advertisement agencies. However, in convergence of telecommunications and broadcasting, we have to consider additional players such as VoD (video on demand) service providers, telecommunication service providers, and various manufacturers of digital picture and sound receivers including PC. It is obvious that entering of new players to moving pictures and sound business changes traditional money flow among the players. Our interest is to know future possible scenarios in terms of money flow among the players. From the manufacturer's point of view, possible technological structures of value chains in the scenarios are specifically interesting points.

Takanori Ida has recently reported economic analysis for broadband demand reflecting significant spread of ADSL and FTTH in Japan[1]. Based on questionnaire to the consumers, interesting analysis is conducted such as derivation of migration paths from narrowband to broadband and derivation of a nested logit model for broadband demand. These are quite innovative economic analysis for the telecommunication market, but the market structure dealt with in this study is rather simple. The models for consumer behavior are suggestive for our problem, but we have to think about the value chains/competitions among players paying attention to the long tail phenomena which are common in the Internet content business.

In order to deal with our problem natures, we are going to introduce an agent approach. Agents in our model stand for market players and consumers. Market players produce the partial products such as content, affiliated content (advertisement), contents integrating and providing services, content transmitting services, and receiver capability. Based on some adequate collaboration, the market players provide consumers with the system products which are meaningful for consumers. On one hand, it is also important to think about collaboration among consumers in order to deal with social network effects. For the successful agent approach, it would be vital to model the non-cost value of products for the consumers.

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Event detection based on classification of empirical probability distributions

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Keywords: event detection, classification, empirical probability distributions, telecommunications

The data that is stored in various information systems can be applied not only for supportng operations, decisions or analysis but also for detection of various events. Events detection can be applied to a wide range of important real-world applications e.g. telecommunications [1], logistics [3], environment [4], medicine [5], etc.

This paper concentrates on the issue of event detection based on classification of empirical probability distributions (histograms) [2]. While existing approaches to event detection concentrate on the use of selected moments or other characteristics of empirical probability distributions, we postulate that full empirical distribution preserves more of needed information then selected moments of this distribution, thus multiple criteria classification of distributions can be most effective in event detection. One of advantages of reference point approaches is that they easily deal with so-called multiobjective trajectory analysis and optimisation; this can be applied to issues of stochastic dominance and their generalisations needed for multiple criteria event detection based on classification of empirical probability distributions. The paper presents also examples of classes of practical event detection problems in which such formulation is useful.

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On supporting virtual prototyping in manufacturing using a service-oriented computing environment

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Keywords: service-oriented architectures, service-oriented computing, Grid computing, manufacturing, virtual prototyping

Virtual prototyping in manufacturing gains more and more importance, since companies competing on the market noticed the increasing cost pressure alongside higher quality requirements. The utilization of virtual prototyping techniques provides an opportunity to reduce the total development costs and the time to market, while simultaneously innovations of both products and its production processes increase the overall quality of the manufactured parts. The monetary effort and the lack of know-how especially in small and medium sized enterprises (SME) which is required to operate such systems lead to a disadvantage in the more and more globalized market.

The paper states the problem of supporting virtual prototyping processes in the manufacturing industry (by the example of casting and sheet metal forming processes in the German automotive supplier industry) and gives a solution approach by utilizing service-oriented architectures and concepts from grid computing. A pilot implementation of the proposed architecture is introduced and evaluated by case studies (in simulation, optimization and clash-analysis) in various manufacturing (casting and sheet metal forming) domains.

A network-effect model for service innovation

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Keywords: network-effect, electronic money, RFID

Most complex systems, including social and biological systems, become more complex with time. Information and communication technologies (ICT) systems are no exception. The Internet has been established as a worldwide communication infrastructure. Many new systems and services have been stacked on the Internet, including WWW, web application systems, and Internet searching services. They are becoming new ICT infrastructures. The piling up of system layers is a typical part of the evolution process of complex systems. Therefore, modeling the diffusion process of a new system layer is an important subject for complex systems.

In this presentation, we discuss diffusion models for new information systems and services that are based on new devices and network technologies. In regard to such information systems and services, their diffusion around the world is not a matter of course. Some invented technologies have become widespread, while others have not.

Several mathematical models have been proposed to explain the bandwagon effect (or network externality) and the critical-mass mechanism. The most fundamental model of the bandwagon effect [1] interpreted the rapid and effortless growth of network products and services, such as the telephone and fax, and their start-up problems. However, the model contains only one variable, that is, it considers one factor for popularization. This is insufficient for high-technology innovation these days [2]. In our presentation, we introduce a network-effect model with multiple variables as an extension of Rohlfs model.

As case studies, we apply the model to several innovative systems and services, including radio-frequency identification (RFID) tag systems, Japanese electronic money systems, and car-to-car communication systems. We also compare case-study models to those of existing systems, such as the fax and bar-code systems. Finally, we discuss the relationship between the diffusion model of a new system layer and system complexity.

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Grid-based modelling in groundwater engineering

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Keywords: Grid, FEM, groundwater modeling

Advances in processing power of modern computer hardware enable the analysis of complex systems by means of simulation. However, the demand for computational power which is driven by real-world problems rises at an even higher rate. In the field of groundwater modeling, increasingly large areas are being simulated and are often represented by complex 3D FEM meshes. Concurrently the performance increase of traditional single CPU systems is beginning to decelerate. Therefore, new techniques have to be used to solve complex groundwater modeling tasks in parallel. However it is a difficult task to apply fine-grained parallelism to the simulation software itself, because its feasibility depends on the mathematical properties of the underlying algorithms. So its scalability is limited, and speedups can often only be achieved on compute clusters with expensive high-speed interconnects. Alternatively, executing several simulation runs simultaneously can utilize parallelism on a more coarse-grained level. This can be applied, whenever several simulations would have to be run consecutively in a traditional, sequential setup.

During the groundwater modeling workflow, this occurs during different lifecycles of the model, like parameter study, sensitivity analysis, and technical model based optimization, e.g. to minimize operational costs of pumping stations while still satisfying constraints like a minimum allowed depth to water table. Each of these tasks typically leads to a large number of model simulation runs, which require no interconnects apart from modifying the parameters and returning the simulation results. Hence, these tasks are qualified very well to be executed in parallel. In the past mainly cluster-based solutions were used, if any parallel computing in groundwater modeling took place. The main disadvantage of cluster solutions is that in general the scalability is limited to the size of the cluster not bound to the problem size. Also the installation and maintenance of clusters are very high priced. Thus an appropriate

infrastructure is required to allocate resources on demand. Grid technology is a promising approach to implement a distributed resource infrastructure. Based on the Service Oriented Architecture (SOA), several services can be realized to solve complex groundwater modeling tasks by linking these services and solving the required simulations on distributed Grid simulation resources. Different services can be provided by particular experts, e.g. an optimization expert will offer several optimization algorithms as service, while a resource provider offers calculation services. Even software licensing may be offered as service. By linking the service offers of different providers, a powerful workflow can be realized to solve even complex and time consuming groundwater engineering tasks in an adequate time.

Support for collaborative multidisciplinary research process - a knowledge base approach

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Keywords: collaborative process, multidisciplinary research, ontologies, knowledge bases

Collaborative research processes

Collaboration in research across disciplines and institutional boundaries is increasingly being promoted for reasons of overcoming unnecessary duplications, addressing shared problems and actively involving stakeholders, to state a few. Major research sponsors like the EU Framework Program and the U.S. National Science Foundation actively promote and invest huge amounts of money on collaborative research projects. However, researchers involved in such research projects encounter many problems. Team members come from various disciplinary backgrounds therefore they may not share the same set of norms and values [1]. Miscommunication arises due to slight difference in meanings of terminologies in different disciplines. In addition, there are other common problems encountered in research in general such as inappropriate use of methods and lack of documentation and transparency [2].

Therefore, like many processes in an organisation, collaborative research projects need to be supported and managed. Currently available project and business process management systems are, however, almost never employed to support collaborative research work. In this abstract we try to identify requirements for supporting collaborative research and describe a solution to meet these requirements. But we first briefly discuss the context in which the terms *collaborative research* and *research process* are used before we proceed to requirements analysis.

There is no generally accepted theory of collaboration. Wood and Gray [3] define collaboration as a process that "... occurs when a group of autonomous stakeholders of a problem domain engage in an interactive process, using shared rules, norms, and structures, to act or decide on issues related to that domain". In their review of collaboration, they frame collaboration in terms of an antecedent – process – outcome model in which the process component is viewed as a "black box". Inside this "black box" an iterative process of negotiation, planning and executions of activities occurs. Here, we take a broader view on collaboration in which we consider collaborative research as an interactive process in which a team of researchers and stakeholders from different domains and disciplines solve complex multi-domain problems.

A process can be defined as a series of actions that need to take place to achieve a set goal. A (business) process is widely understood as automation of routine tasks in which the users' task is limited to some manual or data entry activities. A research process as used here is a set of collaboration activities for guiding (thus not necessarily automating), monitoring and documenting of a research project. In recent years, there is a growing interest in the *people component* of the business process[4][5][6]. The problems identified by these researchers with regard to the lack of support for knowledge workers are also valid for researchers and research work in general.

Requirements for supporting collaborative research

Due to the lack of proper supporting tools, researchers usually rely on a series of custom-made spreadsheets and documents to manage their work and groupware products such as e-mail for collaboration. In light of an apparent lack of support systems made specifically for managing research projects, one may propose the use of standard project, workflow or business process management systems. However, these systems are almost never used in practice. The reason for the lack of adoption of such modern process support systems lies in the discrepancy between the kind of work these systems support and the very nature of scientific research work. Most of these systems mainly support execution of activities in routine production or administrative processes. Research work, on the contrary, has unique characteristics that make current process support systems unsuitable for managing it. The main differentiating characteristics are:

- A multidisciplinary research project is a collaborative, semi-structured process. A research process is usually susceptible to change during process execution while a structured process does not change.
- A collaborative research process is mostly one-of-a-kind with recurring elements. Unlike, a routine workflow process that is executed many times a research process may be executed only once or a few times.
- Research is knowledge intensive work. Researchers need relevant information related to the activity they are doing; they need to share their results to other researchers and end-users. Currently available systems for process support, on the contrary, don't support guidance on how to do the activities of a project, don't allow sharing of information and provide little support to incorporate last minute changes and new insights after a project has been started.

Process support consists mainly of two tasks: defining a process, sometimes called process modelling, and execution of the process; also called process enactment. The three unique characteristics in which collaborative research process differs from a routine process gives rise to specific requirements. Table 1 summarizes these requirements, which can be regrouped into the following major functional requirements:

- A knowledge base for defining collaborative processes and any relevant domain specific knowledge (requirements 1a and 3a).
- A glossary of terms to explicitly define the meaning of potentially ambiguous terms (requirements 1a).
- A collaborative knowledge acquisition tool for collecting and organising knowledge (requirements 1a, 2a and 3a).
- A collaborative process support tool for guiding the research work and monitor the project execution (requirements 1b, 2b and 3b).

In order to provide relevant knowledge about the activities of a process, existing state-of-the-art knowledge should be gathered and structured in a knowledge base. A knowledge base can be defined as a collection of facts, rules, and procedures organized into schemas[7]. The intended meaning of schemas can be captured using ontologies (refer, for instance, [8] and [9] for more information about ontologies). Ontologies can also be used to capture the process models. Using ontologies to represent both process and domain specific knowledge enables to easily create the link between the activities of the process with knowledge items from domain knowledge base.

In collaborative projects, representing the different perspectives of various groups is important to the successful implementation of a given process. The perspective of a group of researchers or stakeholders can be based on their discipline, their role in the project, or any other factor that can be represented as a tree or taxonomy. Representing taxonomy of terms is probably the simplest and most frequently used application of ontologies. Therefore, relevance indicators can easily be structured as an ontology. They are used to indicate whose viewpoint a knowledge item represents or to whom the knowledge item is relevant for[10] and, in so doing, make it possible to filter information based on user needs and preferences. During process execution relevance indicators enable fine-grained authorisation and personalized report generation.

Table 1: Requirements for supporting collaborative research

Collaborative research	Process support	
	(a) Process definition	(b) Process execution
(1) Collaborative and semi-structured	The research process is defined collaboratively usually by the same group of people who will eventually execute the process. Different groups may have different viewpoints on the activities of the process. The process definition should preserve the differing perspectives of the different groups.	A research process is used to guide or advice. It defines the "normal way of doing things". The focus should therefore be on documenting the actions and decision made instead of strictly enforcing the process flow. Collaboration calls for members of a research team to exchange ideas and share experiences. Therefore, the system should enable team members to share their work and receive input from others.
(2) One-of-a-kind	Unlike a routine process, each research project is a unique process. Often team members come from different geographical locations; therefore, a software tool that creates a virtual space for collaboratively defining the research process is vital.	Since each research process is unique, there is almost not enough time and resources to check the correctness and consistency of process definitions. Therefore, process definitions can be error prone. The system should be robust and tolerant to changes in process definitions.
(3) Knowledge-intensive	A research work is always associated with lots of documents. These can be guidelines, standards, manuals etc. Often, the required information is usually difficult to find because these documents are in printed form and difficult to search. Research projects will benefit greatly if these documents are collected, structured and put in a knowledge base.	Research is creative and knowledge-intensive work. Researchers will benefit substantially if personalized and relevant information for the activity they are working on (such as best practices and state-of-the-knowledge) are made available to them.

Defining a collaboratively research process

Like most other process definitions (refer to [11], for the comparison process definition languages), the process definition we proposed consists of a network of tasks and activities. But, unlike most process definition languages, our approach to process definition incorporates features to attach knowledge items to the activities of a process. To capture the different perspective of users each knowledge item and activity is associated with relevance indicators. The use of ontologies as a knowledge modelling technique provides a mechanism for integration among process, domain specific and role and relevance knowledge items.

To actually support a research project, the associated process definition needs to be instantiated using a process support tool. Process instantiation in a project means enlisting project members, assigning members specific roles, specifying deadlines, etc. By the same token, doing an activity means creating

an *instance* of the activity. In a *process instance*, in addition to user and time information, it is necessary to store any relevant documents and data generated during executing an activity along with the activity instance.

Conclusion

A multidisciplinary scientific research project follows a complex process involving team members with different backgrounds and roles. Such projects encounter often many problems due to factors such as differing sets of norms and values, ambiguous terminologies, and differing and often incompatible methods. Besides, like any process, the research process needs to be supported using process management systems. However, widely available project, workflow or business process management systems are not suitable for supporting multidisciplinary and collaborative research projects because these systems are not suitable for supporting knowledge-intensive work in general. In this abstract we identified a (non-exhaustive) list of requirements for supporting collaborative research projects. We described a knowledge base approach based on ontologies to address the requirements.

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An improved analysis support system of open-ended questionnaire data using category-based dictionary

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Keywords: classification, questionnaire data, user opinion, mobile game business

This paper describes a support system for analyzing answers in open-ended questions that users of the mobile game contents reply when they unsubscribe the contents[1][2][3] [4].

The answers of open-ended questions often include the useful opinions for new service. However, the answers are a huge quantity of texts and the most answers are useless opinions (e.g.: "I have a baby!") or typical opinions that the contents provider already understands (e.g.: "My knowledge increased.", "The packet charge is too expensive."). The useful unexpected opinions (the atypical opinions) (e.g.: "Quizzes for kids may be interest.") are only 5% of all answers. It is time-consuming to read all of the texts one by one. Most opinions are needed to know only the number and the outline. However, the provider should not omit to read the unexpected opinion that is a minority. Additionally, since answers are input through cellular phones, they often include many symbols dependent on various kinds of terminals and grammatical mistakes, making them hard to understand. Our research, therefore, aims to create a system that supports the provider to analyze the answers of open-ended questions efficiently.

The main functions of the support system are followings:

- Extraction of atypical opinions and classification of typical opinions: To classify the opinions, firstly, the morphological analysis using "ChaSen" that is free Japanese morphological analysis software is done. Based on the morpheme connection and extraction rules, morphemes are transformed to keywords. For example, "packet" and "fee" are transformed to keyword "packet fee" by the rules. In the typical word database, the combinations of words are set up beforehand. The matching engine compares keywords of opinions with the typical words database. Comparison is done based on the ratio of typical word combinations in sentences of an opinion. As a result, opinions are divided into 53 categories and atypical opinions.
- User interface for analyzing atypical opinions: Atypical opinions having designated characteristic are mapped as cards showing characteristic keywords on the designated two-dimensional plain such as user age vs. subscription period. Two axes can be changed from user's information and singularity of opinion. When one card is clicked, raw text opinion and personal information of the opinion writer are shown in the text information area.

• User interface for analyzing typical opinions: The numbers of typical opinions are counted monthly with opinion categories. They are displayed as the 3D bar graph by selecting categories and months. Using this interface, the analyst can grasp the transition of the number of each categories easily.

However, 61% of opinions classified as atypical opinions by above mentioned method, are out of place. To solve this problem, a new method using a category-based dictionary are developed. The category-based dictionary is generated by extracting the major words of category from existing typical opinions database. The opinions are judged the coincidence with the category-based dictionary. Then, the opinions included in "atypical opinion category" with high coincidence are moved into the correspondent category. By this improvement, the ratio of typical opinions in the "atypical opinion category" is reduced to 49% with scarce miss classification. However, more improvement is desired.

The support system may be applied to knowledge extraction from Web and mail contents and other applications. So, we are planning to universalize the system.

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Statistical framework for dominance-based rough set approach

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Keywords: rough sets, dominance-based rough set approach, isotonic regression, decision theory

In decision analysis, a multicriteria classification problem is considered that consists in assignment of objects to m *decision classes* Cl_t, $t \in T = \{1, \ldots, m\}$. The classes are preference ordered according to an increasing order of class indices, i.e. for all $r, s \in T$, such that $r > s$, the objects from Cl_r are strictly preferred to objects from Cl_s. Objects are evaluated on a set of *condition criteria*, i.e. attributes with preference ordered value sets. It is assumed that a better evaluation of an object on a criterion, with other evaluations being fixed, should not worsen its assignment to a decision class. In order to construct a preference model, one can induce it from a *reference* (*training*) set of objects U already assigned to decision classes. Thus, multicriteria classification problem resembles typical classification problem considered in machine learning [1] under monotonicity constraints: the expected decision value increases with increasing values on condition attributes. However, it still may happen that in U, there exists an object x_i not worse than another object x_k on all condition attributes, however, x_i is assigned to a worse class than x_k; such a situation violates the monotone nature of data, so we shall call objects x_i and x_k *inconsistent with respect to dominance principle*.

Rough set theory [3] has been adapted to deal with this kind of inconsistency and the resulting methodology has been called *Dominance-based Rough Set Approach* (DRSA) [4]. In DRSA, the classical indiscernibility relation has been replaced by a dominance relation. Using the rough set approach to the analysis of multicriteria classification problem, we obtain lower and upper (rough) approximations of unions of decision classes. The difference between upper and lower approximations shows inconsistent objects with respect to the dominance principle. It can happen that due to the presence of noise, the data is so inconsistent, that too much information is lost, thus making the DRSA inference model not accurate. To cope with the problem of excessive inconsistency the *variable consistency* model within DRSA has been proposed (VC-DRSA) [5].

In this paper, we look at DRSA from a different point of view, identifying its connections with statistics and statistical decision theory. Using the maximum likelihood estimation we introduce a new variable consistency variant of DRSA. It leads to the statistical problem of isotonic regression [6], which is then solved by the optimal object reassignment problem [2]. Finally, we explain the approach as being a solution to the problem of finding a decision minimizing the empirical risk.

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Methodology template for acquiring user preferences and decision-making based on hierarchically organized criteria

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Keywords: multicriteria analysis, preferences, decision making, hierarchy, template

The problem of analysis of many hierarchically organized criteria is not new. Unfortunately, no satisfactory approach is known so far. Many different methods are used, but all of them suffer from limitations and fundamental problems. One of the most widely spread methodologies is the Analytical Hierarchy Process (AHP) which fails with linear weighting aggregations. The method presented fits into the stream of methods developed within IIASA, ICCE, JAIST and NIT (e.g. [1]) which were proposed to find a solution that properly addresses the problem.

The algorithm utilizes a bottom-up approach, i.e. the user walks over a criteria hierarchy tree starting from the lowest level criteria towards the root. From the user perspective the algorithm consists of six points:

1. The user is presented with a solution, i.e. he/she sees values (or other properties) of all those lowest level criteria which are subordinate to the considered criterion. Each of the subordinate criteria must be either a lowest level criterion or must have been visited by the user before.
2. For all criteria the first solution (values for the corresponding subset of the lowest level criteria) is generated by the application itself. The following solutions are generated with user cooperation.
3. When a new solution is generated for the criterion, the user is prompted to select from all those generated so far: either a final solution for the criterion or a solution for improvement (at the beginning of the criterion processing the set of solutions includes one solution only). The selection of the final solution ends the processing of the criterion (the selected set of values/properties of the lowest level criteria matches the best user preferences).
4. If the user has selected a solution for improvement he/she is presented with a table which has the current criterion's subordinate criteria in rows and a single column corresponding to the selected solution. He/she is asked for a direction of improvement via pointing to a lowest level criterion which should be upgraded. If no criterion is selected the current solution for the processed criterion is regarded as its default and the application comes to point 3.
5. If the lowest level criterion has been pointed to, the application generates the number of neighbors, i.e. new solutions. Neighbors have better properties of the selected lowest level criterion (and worse for (some) other lowest level criteria) than did the basic solution. Next, the user is prompted to point to the neighbor which best matches his/her preferences. The chosen neighbor is treated as a new generated solution. If the user selects the solution (not a neighbor), then this solution is regarded as the default solution for the processed criterion and the application comes to point 3.
6. The algorithm ends when all criteria have been visited by the user.

The maximum number of neighbors to be presented to the user is given to the algorithm as a parameter. Usually, the total number of solutions visible to the user should not exceed about 7 (see e.g. [3]).

The methodology presented has certain advantages. The first is the possibility of applying different approaches for generating a solution on each criterion level (see presentation of [2]). The number of the lowest level criteria visible to the user varies depending on the processed criterion and gets expanded

as the user moves towards the root of the hierarchy. This way knowledge about user preferences is accumulated during the whole process and subsequent selections include this information. Moreover, such a procedure helps the user to learn the criteria and the relations among them. It also features the possibility to specify preferences by observing the output of previous decisions. Finally, this approach forces the user to adjust his/her preferences as the number of the lowest level criteria increases. At the same time the user is assisted in accomplishing this task.

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On a group multicriteria method supporting analysis and selection of projects applying for the EU co-financing

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Keywords: multicriteria analysis, group methods, decision support, computer-based systems

Poland, as a new member of the European Union, participates in EU structural funds supporting the growth of competitiveness and innovativeness of the weaker regions and assuring social, economic and territorial cohesion. Analysis and selection of development projects which can benefit from the funds is made on a regional level.

In the paper an experience from the case study of the Mazovia region in Poland will be presented. Within the study the complex procedure including formulation of multicriteria problem, multicriteria analysis and selection of the key projects ("key" means the most important for realization of the development strategy of the region) applying for the EU funds in the period 2007-2013 has been proposed. The procedure has been implemented in the Mazovia Bureau for Regional Planning, in the form of interactive sessions with a group of experts and with use of computer-based support. The list of selected key projects has been approved by the Authority of the Mazovia Voivodeship.

Modeling technological change in energy systems – from optimization to agent-based simulation

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Keywords: technological change, energy system, agent-based modeling

Operational optimization models are one of the main streams in modeling practices on energy systems. Agent-based modeling and simulations seems to be another rising stream in the field of modeling energy systems. In either optimization or agent-based modeling practices, technological change in energy systems is a very important and inevitable factor that researchers need to deal with.

In most traditional optimization energy models, technological change has been largely treated as exogenous. Technological change is either reduced to an aggregate exogenous trend parameter (the residual of the growth accounts) or intro-duced in the form of numerous (exogenous) as-sumptions on the costs and performance of future technologies. In such models, for triggering both the adoption and penetration of otherwise un-economic technologies, most of time it is inevi-table to include additional (e.g., environmental or capacity) constraints. Most traditional optimization models are linear optimization models, thus it is easy to get global optimal solutions, even energy systems modeled are quite large and complex, e.g., with hundreds of energy tech-nologies and thousands of parameters. From the middle of 1990s, researchers started to develop optimization models of energy systems with endogenous technological change (e.g., see Gritsevskyi and Nakicenovic 2000, Grübler and Gritsvskyi 2002, Kypreos etc 2000, Ma, 2006, Messner 1997). The most important feature of endogenous technological models is that, as ex-perience in new technologies accumulates, the cost of using them tends to decrease so-called technological learning which is a classical ex-ample of increasing returns (see Arthur 1989). Endogenous technological change models are also called induced technological change models (see Gritsevskyi and Nakicenovic 2000), or LBD (learning by doing) models (see Manne and Leonardo Barreto 2004). With endogenous technological change, it is not necessary to in-clude additional (e.g., environmental or capacity) constraints which are actually at odds with his-torical experience (see Barnett and Morse, 1967) for triggering the penetration of advanced but currently uneconomic new technologies. The resultant mathematical problems of endogenous technological change models are non-convex optimization problems. Some endogenous tech-nological change models also consider uncer-tainties in technological learning (e.g. see Grübler and Gritsvskyi 2002), thus the resultant optimization problems are not only non-convex but also stochastic. Comparing to the traditional optimization models, it is much more difficult to find (especially global) solutions for endogenous technological change models, especially those considering uncertainties. It is necessary to apply some very specific searching techniques (eg, see Manne and Leonardo Barreto, 2004) for finding solutions.

In recent years, agent-based modeling (ABM) and simulations have got increasing concerns by many researchers in the field of modeling energy systems. Agents in ABM can be simply defined as autonomous decision-making entities. ABM is thought as a powerful tool for studying complex adaptive

systems which are systems with multi-ple elements/entities adapting or reacting to the pattern these elements create (see Arthur 1999). In real world energy systems, there are many heterogeneous participating entities involved, and those entities not only interact with each other but also adapt or react to the pattern they create. It is difficult to catch those features related to heterogeneous entities and their interaction and adaptive behaviors with conventional optimiza-tion approaches, equilibrium analysis, and other analytical techniques. ABM is not only a good tool for dealing with those features, but also provides a way for rethinking the dynamics of energy systems. Examples of the applications of agent-based modeling in energy systems include: D.W. Bunn and F.S. Oliveira (2001) used agent-based simulation to develop detailed in-sights into potential electricity market ahead of the introduction of new electricity trading arrangements of England and Wales, and C. Stephan and J. Sullivan (2004) put forward an agent-based model to study the transition of a personal transportation system based on conven-tional fuels to one based on alternative fuel, such as hydrogen. Technological change in ABM can be in various forms. Comparing to optimization approaches, technological change in ABM is not any more the result of a long-term strategic planning, but the result of agent's reacting and adaptive behaviors.

This paper uses three models as examples to ex-plain how technological change could be treated differently in optimization and agent-based modeling practices and compare advan-tages/disadvantages of and different philosophy underlying different modeling practices. The three models are namely traditional optimization model, endogenous technological change model, and agent-based model. For simplicity and comparable, all the three models are based on the same deliberately simplified energy system which is composed of three energy technologies. Each of the three models can be looked as an example of a stream in modeling energy systems.

Multicriteria Analysis of Large Sets of Alternatives

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Keywords: multicriteria analysis, reference point, aggregation of achievements, nucleolar reference point method, lexicographic optimization, energy technologies

The research to be presented has been motivated by the requirements of the analysis of the future energy technologies outlined in Fig. 1.

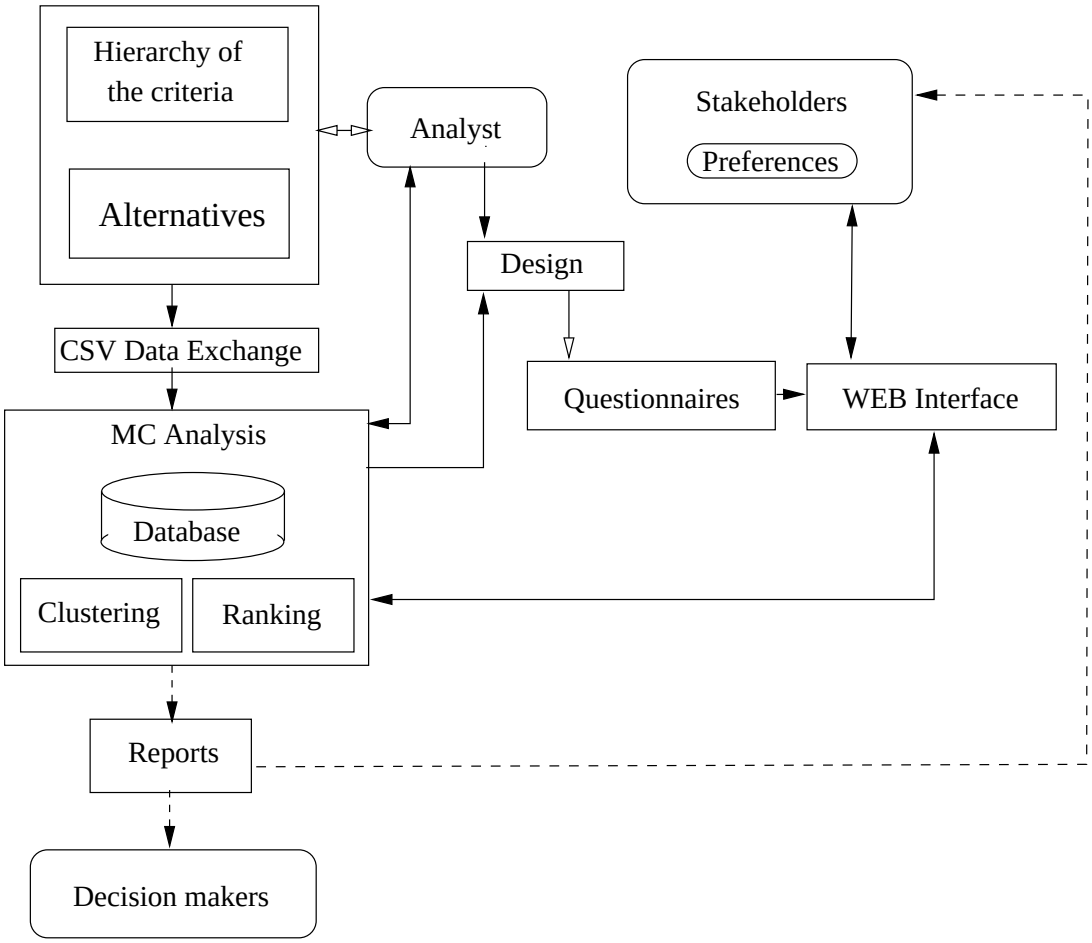

Figure 1: The main components of the process of analysis of alternatives characterizing future energy technologies.

The underlying multicriteria analysis problem is characterized by:

- two-stage analysis:
  1. large number stakeholders (about 1500) having diversified backgrounds and interests,
  2. experts who will analyze the preferences of stakeholders in order to prepare recommendations for future energy technologies.
- large sets of discrete alternatives (about 40),
- large number of criteria (about 40),
- a number of criteria having multimodal value distribution and/or either large (e.g., $[0, \infty]$) or very small range of values.

The requirement analysis [2] clearly shows that we have to deal with a problem that is far more challenging than a typical MCA (MultiCriteria Analysis) problem for which a user analyzes a problem with respect to her/his preferences. Our problem is composed of two stages of analysis:

- diversified stakeholders specify individual preferences, and
- analysts analyze the problem taking into account these preferences (expected to differ substantially amongst groups of stakeholders) in order to identify the characteristics of solutions (either technologies or scenarios) that can help in rational decision-making.

Thus, in fact, one needs two compatible MCA methods:

- to support each stakeholder in a multicriteria analysis of the original problem, which will result in finding a solution corresponding best to his/her preferences; the other outcome of this analysis is a representation of a set of consistent preferences of various stakeholders;
- to support analysts in a consistent exploitation of the elicited preferences for a comprehensive analysis of the original problem.

The presentation will deal with the first type of methods.

The report [1] provides an extensive overview of methods pertinent to multicriteria analysis of sets of discrete alternatives, with a particular focus on large sets and large numbers of criteria. Although many methods for analysis of discrete sets of alternatives exist, none of them is adequate for analysis of the current multicriteria analysis problem considered in the NEEDS project. This might be a surprising conclusion, therefore the report [1] provides a detailed analysis of the features of such methods and compares the features with the characteristics of the problem defined in the requirement analysis presented in [2].

In the presentation we will outline the new methods being developed for the multicriteria analysis that need to meet the requirements listed above. These methods (including the method by B. Kozłowski summarized on page 20 of this set of abstracts) are being currently tested. One of them will be selected for the actual use by the stakeholders of the NEEDS project. However, we plan to post on the IME (Integrated Modeling Analysis) Project Web-site all the methods that will deliver satisfactory level of multicriteria analysis of discrete analysis, and in this way make them available for scientific community.

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Consensus under communication through robust messages leads to Nash equilibrium

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Keywords: communication, revision process, conjecture, S5-knowledge, Nash equilibrium

This article presents the communication system leading to a mixed strategy Nash equilibrium for a strategic form game as a learning process through robust messages in the **S5**-knowledge model associated with a partitional information structure. We show that

Main theorem. *Suppose that the players in a strategic form game have the knowledge structure associated a partitional information with a common prior distribution. In a communication process of the game according to a protocol with revisions of their beliefs about the other players' actions, the profile of their future predictions converges to a mixed strategy Nash equilibrium of the game in the long run.*

Recently, researchers in economics, AI, and computer science become entertained lively concerns about relationships between knowledge and actions. At what point does an economic agent sufficiently know to stop gathering information and make decisions? There are also concerns about the complexity of computing knowledge. The most interest to us is the emphasis on the considering the situation involving the knowledge of a group of agents rather than of just a single agent.

In game theoretical situations, the concept of mixed strategy Nash equilibrium (J.F. Nash [12]) has become central. Yet a little is known about the process by which players learn if they do. This article will give a communication protocol run by the mutual learning leading to a mixed strategy Nash equilibrium of a strategic form game from the point of distributed knowledge system.

Let us consider the following protocol: The players start with the same prior distribution on a state-space. In addition they have private information which is given by a partitional of the state space. Each player predicts the other players' actions as the posterior of the others' actions given his/her information. He/she communicates privately their beliefs about the other players' actions through robust messages, which message is approximate information about his/her individual conjecture about the others' actions to an accuracy ε. The recipients update their belief according to the messages. Precisely, at every stage each player communicates privately not only his/her belief about the others' actions but also his/her rationality as messages according to a protocol,[1] and then the recipient updates their private information and revises her/his prediction. The main theorem says that the players' predictions regarding the future beliefs converge in the long run, which lead to a mixed strategy Nash equilibrium of a game.

The emphasis is on the three points: First that each player sends not exact information about his/her individual conjecture but robust information about the actions to an accuracy ε, secondly that each player's prediction is not required to be common-knowledge among all players, and finally that the communication graph is not assumed to be acyclic.

Many authors have studied the learning processes modeled by Bayesian updating. The papers by E. Kalai and E. Lehrer [5] and J. S. Jordan [4] (and references in therein) indicate increasing interest in the mutual learning processes in games that leads to equilibrium: Each player starts with initial erroneous belief regarding the actions of all the other players. They show the two strategies converges to an ε-mixed strategy Nash equilibrium of the repeated game.

[1] When a player communicates with another, the other players are not informed about the contents of the message.

As for as J.F. Nash's fundamental notion of strategic equilibrium is concerned, R.J. Aumann and A. Brandenburger [1] gives epistemic conditions for mixed strategy Nash equilibrium: They show that the common-knowledge of the predictions of the players having the partitional information (that is, equivalently, the **S5**-knowledge model) yields a Nash equilibrium of a game. However it is not clear just what learning process leads to the equilibrium.

To fill this gap from epistemic point of view, Matsuhisa ([6], [8], [9]) presents his communication system for a strategic game, which leads a mixed Nash equilibrium in several epistemic models. The articles [6], [8] [10] treats the communication system in the **S4**-knowledge model where each player communicates to other players by sending exact information about his/her conjecture on the others' action. In Matsuhisa and Strokan [10], the communication model in the p-belief system is introduced:[2]Each player sends exact information that he/she believes that the others play their actions with probability at least his/her conjecture as messages. Matsuhisa [9] extended the communication model to the case that the sending messages are non-exact information that he/she believes that the others play their actions with probability at least his/her conjecture. This article is in the line of [9], and it highlights a communication among the players in a game through sending rough information, and shows that the convergence to an exact Nash equilibrium is guaranteed even in such communication on approximate information after long run. It is well to end some remarks on the ε-robust communication. The main theorem in this article can be extended into the **S4**-knowledge model and the p-belief system. The extended theorem in **S4**-knowledge model coincides with the theorems in Matsuhisa [6] and [8] when $\varepsilon = 0$. Can we unify all the communication models in the preceding papers ([6], [8], [10], [9])? There is an agenda to further researches.

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Designing an agent to support the retrieval of medical evidence to support emergency physician decision making at the point of care

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Keywords: evidence-based medicine, clinical decision support

It has become widely recognized that evidence-based medicine, "the conscientious, explicit, and judicious use of current best evidence in making medical decisions" [1] is a necessary component of quality health care. However, use of the evidence in everyday clinical practice encounters significant barriers that impede its use. The first obstacle is the problem of information overload in the medical literature with approximately 30,000 articles published annually. A second factor hampering evidence-based medicine is a lack of effective decision support tools deployed in clinical practice. As a result, in many clinical settings the provision of evidence is not integrated with workflow and clinicians have neither the time nor the ability to access relevant documents, especially at the point of care. Finally presenting evidence that is relevant for a specific patient presentation is complicated by the fact that to a large extent, documents contained in repositories of medical literature emphasize a disease-oriented and not a patient-oriented context.

In this research we are exploring methods of supporting emergency physicians by providing relevant patient-oriented evidence at the point of care. To this end we are developing a methodological framework that uses a concept-based query mechanism to retrieve evidence from an online repository of medical literature (the Cochrane Library [2]). The framework is integrated with clinical workflow and automatically captures different facets of patient information as a patient is assessed by a physician and combines this information with proposed treatment options to formulate a concept-based query with which to search for evidence. The concepts relate to the specified disease and the particular patient presentation, where disease-specific concepts are formulated using MeSH (Medical Subject Headings) [3] terminology and are used to reduce the search space of available documents, while patient-specific concepts are captured from the underlying patient ontology and are used to identify those documents that are most relevant for the current patient presentation. Concept-based querying is used as the method focusing attention on the logical content of information rather than entirely on its form. This is significant for highly specialized corpuses such as medical literature where natural language processing techniques have demonstrated many limitations. Similarly concept-based retrieval can expand the semantic richness of textual queries to overcome problems of low precision often associated with text-based querying [4].

A second issue addressed by our research is the presentation of retrieved evidence in a format appropriate for point of care support. Currently the presentation style favored by many information retrieval engines is a ranked list of retrieved information. Such a style is not suited to environments where physicians may lack the necessary time to browse numerous results in order to locate relevant information. Our methodology employs a cluster-based approach for document presentation [5], to allow for faster visual discrimination of relevant evidence. When a final set of documents has been retrieved using a concept-based search, a number of clusters are created by automatically extracting query concepts as textual cluster labels and retrieved evidence is further processed and assigned to the appropriate clusters.

Our concept-based framework for retrieving evidence will be implemented as a cooperating agent within a larger multi-agent application, MET-A^{3}Support-Asthma, that supports complete workflow management and clinical decision making for pediatric asthma in hospital emergency departments. It is an

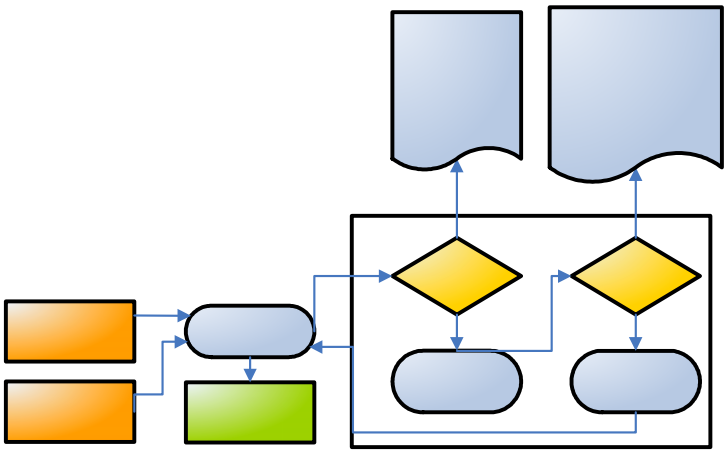

Figure 2: Architecture of the Evidence-Based Agent

extension of our earlier research on supporting emergency triage [6]. The agent is illustrated in Figure 2.

The MET-A^{3}Support-Asthma application combines values of clinical attributes in order to evaluate the severity of an asthma exacerbation. This evaluation of severity is presented at the point of care early in patient management process (about 2 hours after assessment by a triage nurse) and can be used by the physician as an aid in prescribing a treatment for the current patient. Both of these patient-specific pieces of information (severity assessment and treatment) are captured from the underlying patient ontology by the evidence-based agent and automatically translated into a patient-oriented concept-based query and used to mine the Cochrane Library for relevant evidence. This is done in a systematic fashion described below.

Identify the Appropriate Database in Cochrane Library

The first part of the agent's planning task is to identify the correct Cochrane Library to query for evidence. This is achieved using asthma clinical practice guidelines to steer the search for evidence towards the appropriate part of the library. Clinical practice guidelines are derived from research in the Cochrane Database of Systematic Reviews and outline a number of recommended treatments given different asthma exacerbation severities. We have extrapolated all possible severity and treatment combinations from the guidelines to create a lookup table that is consulted by the evidence-based agent. If the severity and treatment combination recommended by the physician is included in the table the search is initiated on the Database of Systematic Reviews, otherwise it is directed towards the Central Register of Controlled Trials.

Formulate a Concept-Based Search

The agent represents concepts related to the disease (asthma) by a combination of MeSH terms that describe the illness at the lowest possible level of granularity. Patient-specific concepts are extracted from appropriate clinical attribute values in the underlying patient ontology. The search terms are bound to different indices of the Cochrane Library where MeSH terms are used to reduce the search space to only those documents where the outlined disease constitutes a major topic of article. From such a reduced repository, patient-specific concepts are used to search the full textual Cochrane indices for each retrieved document.

Create Clusters of Retrieved Documents

Using a concept-based query, the agent retrieves a list of evidence ranked by the Cochrane Library search engine. The list represents the smallest number of documents from the Cochrane library which are relevant for the particular patient presentation given a specified disease. The list cannot be further reduced by text processing techniques given difficulties in parsing the specialized medical texts. Therefore it is necessary to present all retrieved documents, however our framework aims to present the articles in a clustered manner to allow for more effective visualization at the point of care. Retrieved information is organized in a logical manner according to concepts from the patient-specific query by automatically

extracting the clinical attributes used in the patient-oriented concept-based query to create clusters and associated cluster labels.

Assign Retrieved Evidence to Correct Clusters

Finally, the agent assigns documents to relevant clusters by identifying co-occurrences and frequencies of patient-specific concepts within the individual articles. The execution of this task is two-fold. Firstly, retrieved documents must be indexed and secondly, suitable textual queries must be formulated with which to search the generated textual indices.

The search engine we have chosen to index and search retrieved documents is Google Desktop. Retrieved documents from the Cochrane Library are exported as web pages to a local database on the host computer and the agent initiates the indexing functionality of Google Desktop. The second part of the task involves constructing textual queries that can be used to identify patient-specific concepts within the indexed articles. Multiple word queries are automatically constructed by the extracting attribute names and values from clinical attributes used in the patient-oriented concept-based query and combining the instances using a logical AND operator. The textual indices created for the retrieved documents are then searched using the automatically formulated queries and documents are assigned to the correct clusters while maintaining the relevancy scores assigned to the articles by the Cochrane Library search engine. Once all documents have been assigned to a cluster the agent communicates the results to the physician in a structured manner using other agents from the MET-A^{3}Support-Asthma application.

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Knowledge pentagram system and applications

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Keywords: Knowledge management

Many approaches to knowledge and technology creation have appeared for these 20 years. Their specific feature is that they try to utilize the irrational or a-rational creative abilities of the human mind, such as tacit knowledge, emotions and instincts, and intuition (Wierzbicki and Nakamori [1]). In management science a novel approach was developed by Nonaka in 1992, with an international publication: *Knowledge Creating Company* (Nonaka and Takeuchi [2]). This is the now-renowned *SECI Spiral*, with its process- and algorithmic-like principle of organizational knowledge creation. This principle is revolutionary because it stresses steps leading to knowledge increase surely, based on the collaboration of a group in knowledge creation and on the rational use of irrational mind capabilities, namely tacit knowledge, which consists of emotions and intuition.

Historically, the first of such approaches is *Shinayakana Systems Approach* by Sawaragi, with a publication in Sawaragi and Nakamori [3], in the field of decision and systems science. Being systemic and influenced by the soft and critical systems tradition, it did not specify a process-like, algorithmic recipe for knowledge and technology creation, only a set of principles for systemic problem-solving. To these principles belong: using intuition, keeping an open mind, trying diverse approaches and perspectives, being adaptive and ready to learn from mistakes, and being elastic like a willow but sharp as a sword; in short, *Shinayakana*.

Further development of the *Shinayakana Systems Approach* was given in Nakamori [4], in a systemic and process-like approach to knowledge creation called *Knowledge Pentagram System* or *i-System*. The five ontological elements (or subsystems) of this system are *Intervention* (and the will to solve problems), *Intelligence* (and existing scientific knowledge), *Involvement* (and social motivation), *Imagination* (and other aspects of creativity), and *Integration* (using systemic knowledge). True to the *Shinayakana* tradition, there is no algorithmic recipe for how to move between these ontological nodes: all transitions are equally advisable, according to individual needs. Thus, *i*-System stresses the need to move freely between diverse dimensions of creative space.

1. *Intervention*: Taking action on a problem situation. First we ask: what kind of knowledge is necessary to solve the new problem? Then the following three subsystems are called on to collect that knowledge.

2. *Intelligence*: Raises our capability to understand and learn things. The necessary data and information are collected, scientifically analyzed, and then a model is built to achieve simulation and optimization.

3. *Involvement*: Raising the interest and passion of ourselves and other people. Sponsoring conferences and gathering people's opinions using techniques like interview surveys.

4. *Imagination*: Creating our own ideas on new or existing things. Complex phenomena are simulated based on partial information, by exploiting information technology.

5. *Integration*: Integrating heterogeneous types of knowledge so that they are tightly related. Validating the reliability and correctness of the output from the above three subsystems.

From a viewpoint of social science, Zhu explored the *i*-System as a (re-)structurationist model for knowledge management [5]. Viewed through *i*-System, knowledge is (re-)constructed by actors, who are constrained and enabled by structures that consist of a scientific-actual, a cognitive-mental and a social-relational front, mobilize and realize the agency of themselves and of others that can be differentiated as intelligence, imagination and involvement clusters, engage in rational-inertial, postrational-projective and arational-evaluative actions in pursuing sectional interests.

The *i*-System has several applications such as a guideline to develop a knowledge archive system, technology roadmaps, an evaluation system of research activities and environments in academia, and a fresh food management system.

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On sequential approximate multi-objective optimization

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Keywords: multi-objective optimization, sequential approximate optimization, metamodeling, computational intelligence, support vector regression

Since Pareto optimal solutions in multi-objective optimization are not unique but makes a set, decision maker (DM) needs to select one of them as a final decision. In this event, DM tries to find a solution making a well balance among multiple objectives. Aspiration level methods support DM to do this in an interactive way, and are very simple, easy and intuitive for DMs. Their effectiveness has been observed through various fields of practical problems.

On the other hand, in many engineering design problems, the explicit form of objective function can not be given in terms of design variables. Given the value of design variables, under this circumstance, the value of objective function is obtained by some simulation analysis or experiments. Usually, these analyses are computationary expensive. In order to make the number of analyses as few as possible, several methods for sequential approximate optimization which make optimization in parallel with model prediction has been proposed.

In this paper, we form a coalition between aspiration level methods and sequential approximate optimization methods in order to get a final solution for multi-objective engineering problems in a reasonable number of analyses. In particular, we apply $\mu-\nu-$SVM which was developed by the authors recently on the basis of goal programming. The effectiveness of the proposed method will be shown through some numerical experiments.

Creative environments and one selected subsystem for scientific research

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Keywords: scientific knowledge creation, computerized creativity support, software implementation

Knowledge becomes a decisive productive and societal resource. Processes of knowledge creation and technology innovation are gaining increasing attention in research and practice. Universities and research institutes play a vital role in creating and transmitting scientific knowledge (Nakamori, 2004), which is a fundamental source and driver for societal progress and economic development. Thus, enhancing the scientific knowledge creation process in academia has a significant impact on the knowledge economy.

This research to be presented considers the design and implementation of Creative Environments (CE) that support creative processes to be used by researchers at universities or research laboratories. A survey was conducted to investigate user requirements in a scientific research institute (JAIST). We used a multiple criteria formulation and reference profiles for the analysis of survey results; the seven most critical questions and three most important questions were evaluated. Based on user requirements, a prototype CE was developed with following functions: 1) Help in searching for related work; 2) Creative group communication environment; 3) Electronic environment for experiment support; 4) Planning and roadmapping systems.

Gathering plentiful information and knowledge resources for research is an important requirement of researchers (Tian et al, 2006).It confirmed a most basic process of scientific knowledge creation (Hermeneutics: gathering scientific information and knowledge from literature, the web, and other sources, interpreting, and reflecting on these materials), which is represented as EAIR Spiral (Enlightenment-Analysis-Immersion-Reflection) in Triple Helix Model (Wierzbicki and Nakamori, 2006). We developed a module for information and knowledge retrieval to help researchers to gather relevant knowledge or research materials, called Adaptive Hermeneutic Agent (AHA). The AHA presents a simple and intuitive search interface and use familiar search syntax, such as used by popular search engines (like Google, Yahoo). The search support can be extended to the definition of queries that will be automatically executed by the system with a fixed period of time. The query adaptation can be use for ontological information to supplement or modify the query, for example, by adding keywords that are relevant to the searched ontology. The AHA can also filter the query results by using a reinforcement learning approach that relies on a profile of the user's interests. The AHA uses a visual interface for the clustering and graphical presentation of search results. For testing and improving the software tool of AHA, we prepared the COE ontology. A user could extract the knowledge from COE ontology to formulate the outline of user profile, for example, select the domains (keywords) and give the weights for different keywords. Then, the user could gather relevant knowledge and information based on his profile by using search engines set inside AHA. The AHA will do adaptive selection automatically as following steps: text extraction (from MS-word file to text or from PDF file to text); keyword extraction and frequents calculation (extracting keywords from the search results by statistics method); measurement of the similarity of each file and user profile; giving a ranking list including top N results.

Although testing of this system has not been finished yet, diverse tests and tangent applications were already performed. It was found that such CE is more welcomed by junior researchers. Our future work will be centered on the evaluation of the developed prototype CE in the aspects of safety, efficiency and

usability.

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Approaches to identifying latent similarities among organizational accidents: Text-mining method and semiotic process analysis of human work procedures

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Keywords: text mining, semiotic processes

As known as "Year 2007 Problem" in Japan, decrease of opportunities for expertise/skill transfer in organization is becoming a considerable social concern, and some urgent countermeasures to that problem are seriously requested, especially in manufacturing industries. It is said that most of the troubles that industries encounter could be avoided if the prior experiences concerning with the analogous troubles were shared by the members of the organization and generalized lessons were learned from the prior cases. For this purpose, many organizations have attempted to construct a database that stores the s*hiyarihatto* ncidents (i.e., near-miss incidents, that might be led to more serious accidents), to let it be shared by the members of the community, but it is not utilized well as the designer expected. This is due to the fact that accessibility to the constructed database is not well, and utility of such a database depends much upon the user's ability of interpreting the items stored therein. To let this match with the user's needs, some more advanced support for this interpretation phase is essentially needed.

This study investigates into an effective usage of knowledge bases storing a number of account records, in order to let them distributed and shared among community members [1]. We mainly focus on extracting some latent but commonly shared analogous structures with respect to human errors out of incidents/accidents stored in the "Failure Database" [2]. For this purpose, we are adopting two approaches; one is a bottom-up approach of identifying latent similarities out of documented data, and the other is a top-down approach of hypothesis-driven investigation into the process-oriented analysis of a particular incident/accident's occurrence.

In the former approach, a text-mining approach is applied to the documents stored in the database and analogous relationships among accidental cases are identified in spite of their superficial irrelevance. Those "latent but common" structures are visualized as a network, which provides the users with new cues for in-depth analysis of priorly experienced failures. The results of the latent similarities among more than 100 incidents detected using this method are presented, and the limitations of this bottom-up approach is discussed. To supplement this, we further propose a second approach based upon an activity theory. We adopt a new method to analyze transformation processes of work procedures for on-site workers engaged in organizational activities, based on the concept of the four levels of contradictions. Various contradictions, i.e., misfits between components of the activity system, might arise out of and propagate throughout their activities, then induce some sorts of changes in the procedures for the better or for the worse. The proposed method, focusing on the negative aspects of such procedure transformation, represents every phase of a changing activity in terms of a diagrammatic triangle of Engestrm's activity theory [3], thereby visualizing the process of its changing with latent contradictions can contribute to the in-depth analysis of organizational accidents [4]. The criticality accident occurred at the nuclear fuel conversion facility of JCO is employed for an illustrative case to explain this method's capabilities.

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Supporting stakeholder and public participation aspects of multidisciplinary collaborative processes

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Keywords: stakeholders, public participation, collaborative processes, ontologies, ProST

Participatory aspects in collaborative processes

At present, many problem-solving teams address problems of increasing complexity, which calls for a multidisciplinary problem solving approach. Often these teams consist of scientists and professionals with different disciplinary backgrounds, who play various roles, i.e. manager, decision maker, modeller, domain expert, auditor. Collaboration in such teams is difficult, due to a variety of reasons, including miscommunication and malpractices. Model-based water management is such a *multidisciplinary collaborative process* and a methodology to handle associated problems can consist of ontologically structured guidance and project execution support by tools (Scholten *et al*., 2007). Collaboration processes are further complicated by an increasing awareness of the role of stakeholders and interested members of the public (Pahl-Wostl and Hare, 2004, Ridder *et al*., 2005). Policy making evolves from bureaucratic and instrumental approaches to more participatory approaches, creating room for contributions by those people and organisations affected by policy plans (Castelletti and Soncini-Sessa, 2005). The importance of stakeholder and public participation is most prominent in model-based problem-solving, decision making and planning processes, in which clear knowledge and expertise gaps can be distinguished between scientists and professional experts on the one hand and stakeholders affected by or affecting the decision on the other hand.

Stakeholder and public participation can be defined as *allowing people to influence the outcome of plans or decisions* (Henriksen *et al*., submitted). Participatory processes with stakeholder and public participation in complex decision making or planning can have three levels of involvement: (1) being informed, (2) being consulted and (3) active involvement, i.e. discussions, influence on the policy agenda, participatory design of solutions, involvement in decision making and participating in decision or planning implementation (Pahl-Wostl, 2002, 2005, Pahl-Wostl and Hare, 2004, Ridder *et al*., 2005). There are several motives for stakeholder and public participation, summarized by Enserink & Monnikhof (2003): (1) it may improve the quality and effectiveness of policy proposals, (2) it may increase support for possibly controversial policy proposals and (3) it may enhance the involvement of specific social groups in democracy. Moreover, the Water Framework Directive (WFD, EU based legislation on river basin management) enforces stakeholder and public participation at the first two levels (information and consultation) and recommends a more active participation (EC, 2003). Stakeholder and public participation has to be seen in the context of *social learning* that precedes any collaborative decision-making (Pahl-Wostl and Hare, 2004).

Collaborative support technology

To support defining multidisciplinary collaborative processes and subsequently their execution and evaluation in projects, a collaborative support technology has been developed (Scholten and Kassahun, 2006). The collaborative support framework consists of an *ontological knowledge base* (KB), server applications and a client application (Figure 1). The KB is organised into ontological layers, which structure and divide the knowledge content over ranges from general (*layer 1*: general process knowledge) to very specific (e.g. *layer 3*: modelling knowledge for water management or knowledge on water stress mitigation). The general process ontology in *layer 1*, decomposes a process into *steps*, steps into *tasks*, tasks into *activities* and *methods*, instrumental to perform an activity. Tasks and activities can be organised into *domains/disciplines* and users can have roles in a process. These concepts can be used and were found adequate to define processes.

The *KB-editor* facilitates setting up and maintaining one or more knowledge bases and serves as front-end of the ontological KB implemented in the ontology editor and knowledge base framework Protégé (Kassahun and Scholten, 2006). *ProST* (i.e. Process Support Tool) has a similar, yet more extended and flexible functionality compared to its precursor MoST (Scholten *et al*., 2007). It serves as client application for each of the team members that cooperate within a project. All team members use their client application to get guidance from the KB and monitor the project in a project journal, which is shared by all team members. Adaptations to the project journal, made by simultaneously working team members, are synchronized by the project server application.

In order to mix technical, science oriented processes with softer socio-economical aspects the participatory elements have to be included explicitly with the KB-editor at the process defining stage as a separate *task* (group of activities that helps to achieve specific goals) or as an *activity* (what a team member has to do to accomplish one or more goals of a task). These tasks are thus connected to the other tasks and activities. Such participatory tasks or activities can be supported by methods and tools as summarized by Ridder *et al*. (2005).

Results

Support of multidisciplinary collaborative processes with the ProST technology has been tested so far for two fields of application and some interests have been shown for others. MoST (the precursor of ProST) has been developed in the HarmoniQuA project (Scholten *et al*., 2007, `http://www.harmoniqua.org`) and has been used in 21 test case studies related to model-based for water management. In this project a KB has been filled with modelling knowledge. *Stakeholders* and *public* have been included in the list of user types (next to *(water) managers*, *modellers* and *auditors*). The roles of these two user groups are rather limited, focussing on transparency of the process, which facilitates informing and consulting these groups. In *review tasks*, at the end of each modelling *step* (a *step* is a group of coherent *tasks*) stakeholders and public participate in decision making within the modelling process. Co-design or co-modelling (i.e. participation in the modelling process equivalent to professional modellers) is not explicitly incorporated.

In Mediterranean countries, but also in other parts of Europe and the rest of the world, climate changes accelerate water stress, i.e. a limited availability of water resources of decreasing quality. The AquaStress project (`http://www.aquastress.net/`) aims at mitigation of these problems by delivering interdisciplinary methodologies enabling actors at different levels of involvement and at different stages of the planning process to mitigate water stress problems. The project draws on both academic and practitioner skills to generate knowledge in technological, operational management, policy, socio-economic, and environmental domains. The ProST technology is used to define and support water stress mitigation at two test sites (the Velt and Vecht river basin (Netherlands) and the Iskar river basin (Bulgaria)) with a strong emphasis on the participatory role of stakeholders and public. For this purpose the water stress mitigation process has to be defined in cooperation with all parties involved.

Support of the implementation of the Water Framework Directive in all EU countries by the ProST technology is proposed in Henriksen *et al*. (submitted). This would require an extension of the tech-

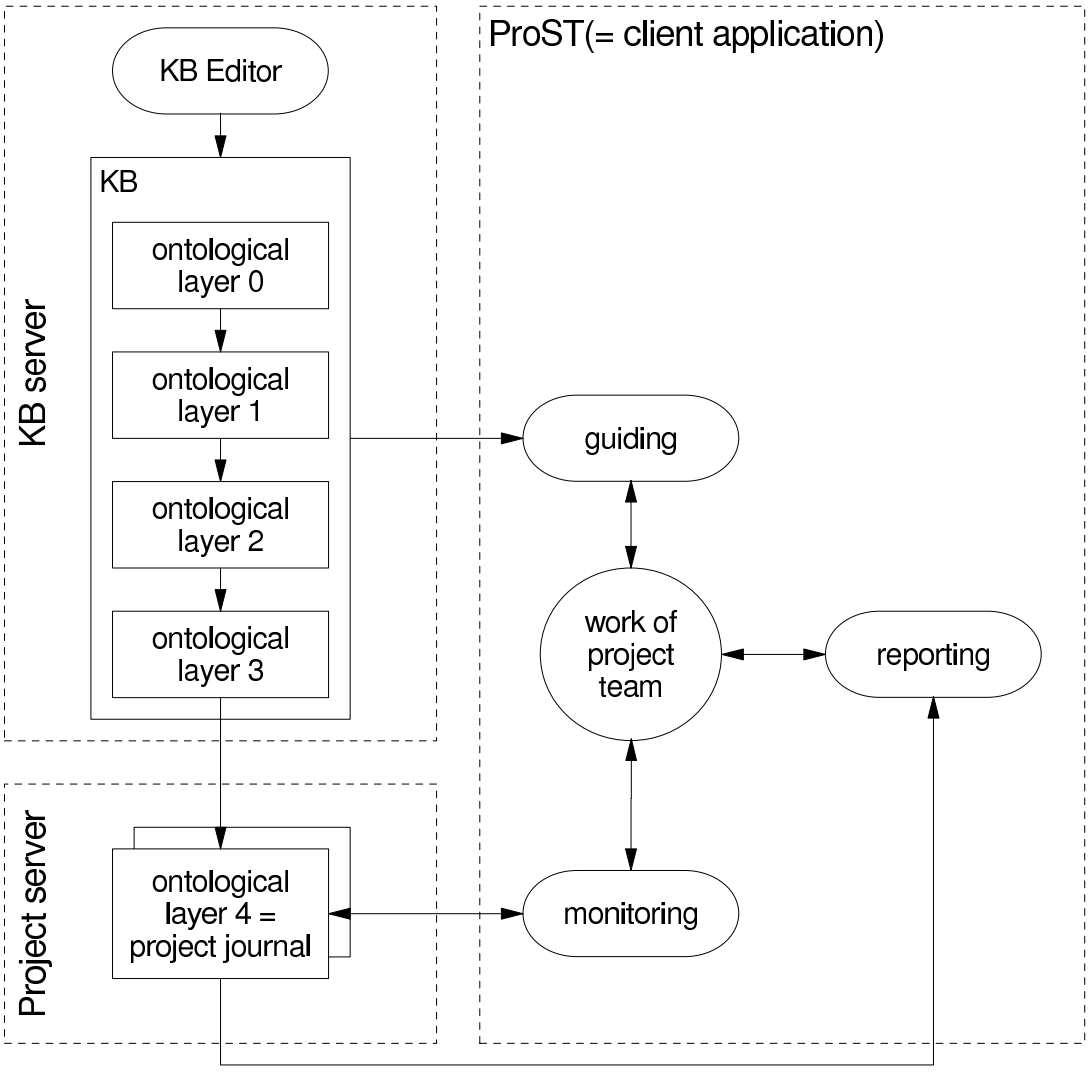

Figure 3: Client-server architecture with ontological process KB on a central server, ProST as process support tool and its major functions (guiding, monitoring and reporting). Process journals are located on a project server. Depending on the content at ontological level 2 and 3, the KB and ProST can be used for modelling (e.g. HarmoniQuA) or for other processes, e.g. AquaStress (adapted from Scholten *et al*., 2006).

nology allowing integration of processes (e.g. modelling, planning, environmental monitoring, measure evaluation). If this would be realized, ProST and the KB-editor have to support integration of processes into a complex integrated project with sufficient flexibility that allows regular adapting the process definitions.

Recently some interest has been shown by the EU-financed project NeWater (New Approaches to Adaptive Water Management under Uncertainty[3]), the EU-funded Spicosa project (Science and Policy Integration for Coastal System Assessment[4]), and several national projects in Denmark, UK and the Netherlands.

Challenges

The ontological technology for support of multidisciplinary collaborative processes is promising, but there are some loose-ends left hindering a more complete deployment and use. Based on the lessons learned so far, there is a need for flexible adaptation of processes during their execution in projects. This is not needed for modelling, as modelling is a rather well known process, on which scientists and professional modellers can rather easily agree on its definition. Other processes are less clear definable, which introduces the risk that teams working in a project perceive the existing definition (realized at the start) as incomplete or inadequate. This is the case in both AquaStress case studies and therefore preliminary features are realized to support adapting the process during its execution in a project. Some technologies for process support allow defining processes with parallel tasks. Often these technologies are based on Petri Nets (Van der Aalst and Van Hee, 2004). The ProST technology allows parallel activities, but tasks have to be executed serially (although users can also do tasks in arbitrary or preferred order). A next challenge to improve the ProST technology is related to coupling of two or more processes, useful to support complex collaborative processes, consisting of several, already defined processes. Implementation of the Water Framework Directive is an example of such a process, as it combines modelling with various other process elements including planning. The process is repeated in cycles of 15 years.

A major challenge for the ProST technology is related to user appreciation and ease of use. Software tools should not require a steep training curve, as this does not encourage its use. This is especially true for the group stakeholders and public, the main entities in participatory processes. They are typically incidental users, lacking experience in the scientific aspects that are associated with the process at hand. Moreover, stakeholders and public are usually not involved in defining processes and do not have a good overview, which makes their involvement completely different from all others. Although not tested so far, we claim that expert mediators can fill a gap between professional team members and the inexperienced stakeholders and public. In this way, the ProST technology facilitates stakeholder and public participation in a wide variety of complex, multidisciplinary collaborative processes.

Acknowledgement

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Integration of knowledge and analytical model analysis in the area of facility location in postal logistics

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Keywords: knowledge engineering, analytical models, facility location

The focus of *model-related-work* at the Deutsche Post Chair of Optimization of Distribution Networks is the elaboration of optimization models and solution approaches for Distribution Networks in Postal Logistics and Supply Chain Design. There are 4 main classes of optimization problems in this application area:

- facility location,
- location routing,
- service network design and vehicle routing and scheduling problems.

The main characteristics of the models developed in the field of Postal Logistics and SCM are:

- Most of the optimization problems are NP-hard (the exceptions are known of course).
- Problem instances are ”large to very large scale”.
- Special structures are present (e.g. patterns of constraint types).

Concluding exact methods are successful in special cases or smaller instances only, commercial solvers can not deal with the very large scale real world applications in a reasonable way. Therefore, the world of heuristics and meta-heuristics complemented by high quality lower bounds (for minimization problems) seems to be the only possible approach to solve the real world problems.

Within the presentation we will propose to elaborate a modeling environment which helps a human model developer to use the expert knowledge about the respective domain and the expert knowledge about the modeling process as well. Such an modeling environment does not exist today. But, today it seems to be possible to design and to implement such an environment by integrating knowledge based methods (expert systems technology) and techniques dealing with analytical (e.g. algebraic) models. There is a need to restrict the domain and therefore we will focus on the field of ”Facility Location” problems which are very important in the strategic planning phase of the applications in Postal Logistics mentioned above. We will outline the domain knowledge in this field and illustrate why it is so important to implement the experts knowledge about models, their properties, the respective solvers and also external expert knowledge about desired properties of solutions which can not be formulated within the analytical models. We will illustrate our approach by presenting a strategic planning approach for Distribution Networks in Postal Logistics.

Multiobjective multiclass Support Vector Machine for pattern classification

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Keywords: multiclass classification, support vector machine, multiobjective optimization

Recently, some kinds of extensions of binary-class support vector machines (SVMs) have been investigated for multiclass classification. Among these extended models, the "all together" method is an extended SVM proposed by Vapnik (1998) or Guermeur (2000), where all patterns are classified into corresponding classes by using piece-wise linear functions. However, the model is not correctly formulated as an optimization problem which maximizes margins between each classes. Therefore, we propose a multi-objective model which maximizes all margins and a new SVM described as a mathematical programming problem.

Original model

In this paper, we consider the following multi-classification problem: For given data: $D = \{x^i, y_i\}, i = 1, \ldots, m$, where $x^i \in \Re^n$ is a input pattern and $y_i \in K := \{1, \ldots, k\}$ is a corresponding class, we construct a classifier which classifies each pattern into the corresponding class.

$$f(x) = \arg\max_p w^{p\top} x + b^p.$$

Here, suppose that data D are piecewise linearly separable, which means that for all $q \neq p$, $p, q \in K$ there exists $w = (w^{1\top}, \ldots, w^{k\top})^\top$, $b = (b^1, \ldots, b^k)^\top$ such that

$$(w^p - w^q)^\top x^i + (b^p - b^q) > 0,\ i \in I^p, \tag{1}$$

where I^p denotes an index set defined by $I^p := \{i \mid y_i = p\}$.

Then,

$$(w^p - w^q)^\top x + (b^p - b^q) = 0, \tag{2}$$

is the hyperplane which separates classes p and q. The distance between the hyperplane (2) and the nearest patterns in classes p and q to the plane is called *margin*, which is defined by

$$d_{pq}(w, b) = \min \left\{ \min_{i \in I_p} \frac{|(w^p - w^q)^\top x^i + (b^p - b^q)|}{\|w^p - w^q\|},\ \min_{i \in I_q} \frac{|(w^p - w^q)^\top x^i + (b^p - b^q)|}{\|w^p - w^q\|} \right\},$$
$$q > p,\ \ p, q \in K.$$

Support vector machine (SVM) is a model which maximizes margins between all pairs of classes to obtain the generalization ability.

Now, let us focus on the "All together" method proposed by Vapnik or Guermeur, which is one of extended SVMs for multi-classification. In this model, it is assumed that any hyperplane such that (1) can satisfy the normalization condition:

$$\min \left\{ \min_{i \in I_p} \left| (w^p - w^q)^\top x^i + (b^p - b^q) \right|,\ \min_{i \in I_q} \left| (w^p - w^q)^\top x^i + (b^p - b^q) \right| \right\} = 1,$$
$$q > p,\ \ p, q \in K. \tag{3}$$

Therefore, by using the following relations,

$$d_{pq}(w,b) = \frac{1}{\|w^p - w^q\|}, \quad q \neq p, \quad p,q \in K$$

SVM model for "all together " method is proposed as follows:

$$\text{(O)} \quad \begin{array}{ll} \min\limits_{w,b} & \dfrac{1}{2}\displaystyle\sum_{p=1}^{k}\sum_{q=1}^{k}\|w^p - w^q\|^2 \\ \text{s.t} & (w^p - w^q)^\top x^i + (b^p - b^q) \geq 1, \quad i \in I_p, \quad q \neq p, \quad p,q \in K. \end{array}$$

However, (3) does not hold generally, and thus model (O) does not mean maximization of margins.

Proposed model

Therefore, we consider a new formulation of the SVM model which can maximize margins.

First, since our aim is to maximize more than one margins, we formulate this problem as a multi-objective optimization problem:

$$\text{(M)} \quad \begin{array}{ll} \max\limits_{w,b} & d(w,b) \\ \text{s.t.} & (w^p - w^q)^\top x^i + (b^p - b^q) \geq 1, \quad i \in I_p, \quad q \neq p, \quad p,q \in K, \end{array}$$

where $d(w,b) = (d_{12}(w,b), d_{13}(w,b), \ldots, d_{(k-1)k}(w,b))^\top$.

Since this model (M) is a fractional multiobjective programming problem, it is difficult to solve it. Thus we introduce a new variable $\sigma = (\sigma_{12}, \ldots, \sigma_{(k-1)k})^\top$ and a vector-valued function $\theta(w,b,\sigma) = (\theta_{12}(w,b,\sigma), \ldots, \theta_{(k-1)k}(w,b,\sigma))^\top$ with

$$\theta_{pq}(w,b,\sigma) = \frac{\sigma_{pq}}{\|w^p - w^q\|}.$$

$$\text{(M}') \quad \begin{array}{ll} \max\limits_{w,b,\sigma} & \theta(w,b,\sigma) \\ \text{s.t.} & (w^p - w^q)^\top x^i + (b^p - b^q) \geq \sigma_{pq}, \quad i \in I_p, \quad q > p, \quad p,q \in K, \\ & (w^q - w^p)^\top x^i + (b^q - b^p) \geq \sigma_{pq}, \quad i \in I_q, \quad q > p, \quad p,q \in K, \\ & \sigma_{pq} \geq 1, \ q > p, \ p,q \in K. \end{array}$$

We can prove the following theorem.

Theorem If (w^*, b^*, σ^*) is a Pareto optimum of (M'), then (w^*, b^*) is a Pareto optimum of (M). Conversely, (w^*, b^*) is a Pareto optimum of (M), then $(w^*, b^*, \sigma(w^*, b^*))$ is a Pareto optimum of (M'), where

$$\sigma_{pq}(w,b) = \min\left\{ \min_{i \in I_p} \left| (w^p - w^q)^\top x^i + (b^p - b^q) \right|, \min_{i \in I_q} \left| (w^p - w^q)^\top x^i + (b^p - b^q) \right| \right\}, \quad q > p, \ p,q \in K.$$

We willdiscuss how to solve (M') in the paper.

Models of knowledge creation processes and ontological engineering

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Keywords: ontological engineering, tacit and explicit knowledge, micro-theories of knowledge creation

Between diverse micro-theories and related models of knowledge creation for the needs of today and tomorrow – as distinct from classical philosophical macro-theories of knowledge creation on long term historical perspective – we observe today an interest of technology, systems theory, computer science and management science in reciprocal relations of tacit (emotive, experiential, intuitive) knowledge and explicit or rational knowledge, see (Nakamori and Sawaragi 1990), (Nonaka and Takeuchi 1995, together with the SECI spiral model of knowledge creation processes), (Nakamori 2000), (Gasson 2004, together with the OPEC spiral model), etc. This trend might have diverse interpretations; for example, in philosophical terms it can be interpreted as a pragmatic approach to metaphysics.

In Japan Advanced Institute of Science and Technology (JAIST) a special research programme have been addressing this issue, called 21st Century COE Program Technology Creation Based on Knowledge Science; in this programme, many new results concerning micro-theories of knowledge creation were obtained. The concept of Creative Space (Wierzbicki and Nakamori 2006) was introduced in this programme as an attempt to synthesise such diverse micro-theories. The concept of Triple Helix of academic knowledge creation combines three spirals: hermeneutical EAIR spiral of analysis and interpretation of scientific texts, experimental EEIS spiral of performing experiments and interpreting their results, and intersubjective EDIS spiral of debating and discussing research results. These three spirals represent main academic processes of knowledge creation at universities and research institutes, as distinct from organisational processes of knowledge creation in business and purpose-oriented or ganisations, represented by the SECI spiral, OPEC spiral and DCCV spiral of older (but only recently formulated as a spiral) process of brainstorming. The new idea of Nanatsudaki model of knowledge creation processes (Wierzbicki and Nakamori 2007) represents an attempt to derive pragmatic conclusions from such analysis and synthesis of micro-theories of knowledge creation, through a combination of seven spirals (setting goals in OPEC spiral; hermeneutics in EAIR spiral; socialization in SECI spiral; brainstorming in DCCV spiral; debate in EDIS spiral; roadmapping in I-system spiral, see Nakamori, 2000; experimenting in EEIS spiral) in an order suitable for an organization of large research projects. The Nanatsudaki model has a prescriptive, not descriptive character; it is based on the experience of its authors in management of creative scientific activity, but expresses an order of activities suggested for organizing a large research project.

Such models are related to and have an impact on ontological engineering and creating catalogues of keywords or vocabularies of concepts characteristic for a given field of knowledge or a research organisation. The basic difficulty of such engineering is namely related to the fundamental difference between grouping or clustering keywords relying on frequencies of their use or co-occurrence (thus expressing explicit knowledge), and a classification based on the experience and intuition of experts or managers of a given research institution (thus expressing tacit knowledge). However, the micro-theories of knowledge creation discussed above analyse the reciprocal relations of tacit, emotive and intuitive knowledge with explicit and rational knowledge. Thus, we can use them to support overcoming this fundamental difficulty of ontological engineering, see e.g. (Tian et al. 2007); we can also combine them with the known techniques of mind-mapping (see, e.g., Kadzielski 2007) that helps to express tacit

expert knowledge. Both these recent advances leave open, however, the final stage of combining tacit and explicit knowledge, top-down and bottom-up ontological results. This paper includes suggestions of supporting such final combination.

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