PROACTIVE DECISION-MAKING MECHANISM BASED ON MINING TECHNOLOGY

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Abstract. *The main idea of this study is to connect the possibilities of mining technology with the methodology of proactive management by social and economic systems. The permanent process of complication of all spheres of social life requires improving the management forms and methods. Modern methods of decision support, appropriate information technology make it possible to improve the classical approaches, one of which is proactive management. Taking into account the limits of classical methods, proactive management should be chosen as an appropriate mining technology that can automatically extract the new non-trivial knowledge from data in the form of patterns, relationships, laws, etc. This synthetic technology combines the latest achievements of artificial intelligence, mathematics, statistics, heuristic approaches, including Data Mining, OLAP and others. Using the mining technology enables: to implement data monitoring, preparation and analysis (collection and presentation of data, detection of situations), to identify problem situations (to recognize patterns of problem situations; to correlate the pattern of the current situation with patterns of problem situations; to determine the structure of the problem situation, to identify factors and relationships), to prioritize the problems, trends and challenges, their expectations, effects (to predict the situation development with managerial influence and without it), to pose the tasks (to analyze deviations in terms of activity; to define goals, criteria, operating conditions) and so on. The following models (using the methods of "nearest neighbour", rules induction, causal networks, statistical methods, associations, neural networks, decision trees, etc.) can be used: cluster allocation situations, classification of patterns, models of situation identification, pattern recognition models, prediction models, optimization models, causal relationships models.*

Key words: *proactive management, mining technology, decision support, mathematical model*

Introduction

The modern management practice employs quite a wide range of methods and instruments which allow an effective management of social and economic systems (SES). However, the rate of changes in the world, their incredible complexity and close relations with all spheres of human life necessitate a constant search of new, more effective, more modern methods and instruments of economic activity organization and management.

Preventing the SES transition into the problematic state and finding an efficient response to problematic situations depend on the effective organization of the situation recognition process, the ability of the decision-making mechanism in a short space of time to characterize the problem. The use of the proactive management conception

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provides for an early diagnostics of problematic situations and realization of oppropriate measures of their prevention (Plunkett, Hale, 1982).

The purpose of proactive management is formation of the SES ability, using information obtained by monitoring, data acquisition, generalization and analysis about its current functioning and changes taking place in the environment, to effectively perform the current and perspective tasks whose consequences provide for the ability of the further system development, stability in achieving competitive advantages.

Modern information systems, which are widely used in all areas of human activityies, allow to store large data arrays about the past and current SES functioning and its surroundings. That is why nowadays first of all there arises the problem of access to the large volumes of accumulated information necessary to solve proactive management tasks.

The proactive mechanism of management decision-making modeling is a complicated interdisciplinary task. Its solution was significantly activated by the development of applied system analysis methods, artificial intellect, information technologies (Turban, Sharda, 2010).

Scientists' efforts in this direction led to the development of a number of methods of proactive management, mathematical models allowing to describe some aspects of social and economic phenomena (Andreeva, 2005; Taylor, 2007; Podsolonko, 2007; Abdikeev, 2010).

The need of a new instrumentation for the proactive management of decision-making modeling in the SES is conditioned by the inability to solve a number of important problems, first of all process forecast, description of phenomena and decision-making when the classical instruments are impossible to use because of complicated intertwine of diverse, considering social-psychological. New and modernized statistical methods, new technologies and instruments of inductive information processing, combined with the power of modern computers, have provided for a breakthrough in the empirical-inductive methodology and were implemented in the form of the mining technology.

Taking into consideration the limitations of classical methods, while solving the tasks of proactive management decision-making mechanism modeling, it is appropriate to involve the mining technology which is able to automatically extract from the data new non-trivial knowledge in the form of models, dependences, laws, etc.

The aim of the study was to justify the theoretical and methodological foundations and conceptual positions of the proactive management decision-making mechanism based on the mining technology, selection of appropriate methods, tools and models.

Relation between the processes of proactive management and mining technology

Mining technology (MT) is an artificial technology which combines the latest achievements of artificial intelligence, numerical mathematical methods, statistics, heuristic approaches. Its methods include data mining, text mining, OLAP, knowledge

discovery, intelligent analysis data, etc. (Maimon, 2005). The selection of the intelligent analysis as a means of modeling proactive mechanisms is based on its properties listed below:

- the ability to describe multifactor dependences due to iterative selection mechanisms of unknown variables;
- the ability to consider poorly formalized parameters;
- the absence of limits of the number of input and output parameters;
- the ability of respective models to "remember" the processes that occurred in the past;
- the possibility of model addeducation with the appearance of new timeline data;
- admissibility of different dimensions of the input parameters, their diversion, heterogeneity, nonstationarity;
- full automation of the process of creating a formal model;
- saturation of the market with the software for mining technology implementation.

The mining technology, like any other cognition method, has a number of drawbacks: the need of a large set of input data for successful training; forming a model in latent form ("black box"); a significant percentage of false results, the use of special databases, etc. For many years, there has been a controversy between scientists about the advantages and disadvantages of intellectual analysis, but the facts of a successful use of technology in scientific, technical, economic and social spheres are an important confirmation of the viability of this approach.

The basis of the proactive management techniques is the process approach, when the main accent is put on a certain sequence of manage actions, providing a basis for the application of logic, reasoning and analysis about the problems.

Proactive management covers the following basic processes: causal analysis, decision-making, programme analysis, and situation review (Diagram 1). These processes are classified by time (past, present, future), each of them has its own orientation and contains a sequence of steps (Diagram 2), and a set of techniques that can be used separately and in sequence. All of these processes are interrelated.

The basis of all proactive management processes is a system functioning data analysis, and the quality of such an analysis determines the success in timely spotted problematic situations, ways to ovoid a search, elucidation of cause–effect relationships among the events.

The modern state of the methods of processing and analysing information development allows to work with large amounts of data and to make an in-depth analysis of data related to the problem. The modern analytics combines the power and complexity, including statistics, profiling, pattern recognition, behavioural analysis, time series analysis, predictive modelling, visualization, analysis of cause–effect relationships, etc. Using mining instruments makes it possible to improve the methodology of proactive

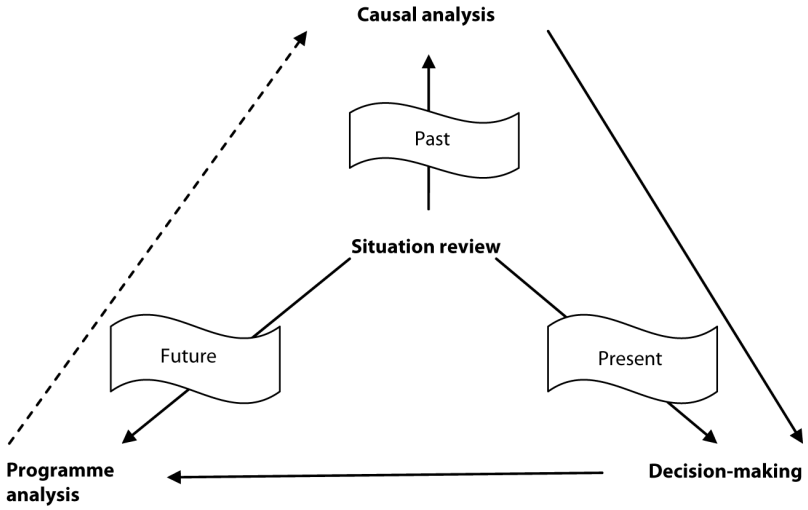

DIAGRAM 1. **Interrelation among proactive management processes**
Source: (Plunkett, Hale, 1982)

management carrying out its basic processes by relevant methods of template discovery, predictive modeling, forensic analysis (Diagram 2).

Theoretical-methodological and methodical levels

The theoretical-methodological and methodical level of the proactive mechanism of the decision-making concept based on the mining technology is defined by grounding the possibility of analysis at each process level and relations among the processes.

Management tasks largely depend on the situation, which may be problematic due to the malfunction of socio-economic, political and other mechanisms, inadequate management structures and errors in management processes. Therefore, for proactive management decision-making realization, it is necessary to develop effective methods of identifying problem situations.

The important point is an early detection of the problem situations long before they start acting. The diagnosis mechanism takes into account the recurring problem situations, logically expected and new changes with a different frequency of occurrence, determines the degree of threat to these changes, accelerating the speed of response to the changes that may adversely affect the SES activity.

The difficulty in identifying problem situations in the SES is that at the early stages the monitoring data on the deterioration of performance are fragmented. Hence, the task of reconstructing a coherent picture on the basis of fragmentary data and a qualitative interpretation of the obtained image of the situation from the perspective of its impact on the SES during its development arises. To solve this problem, it is appropriate to use MT

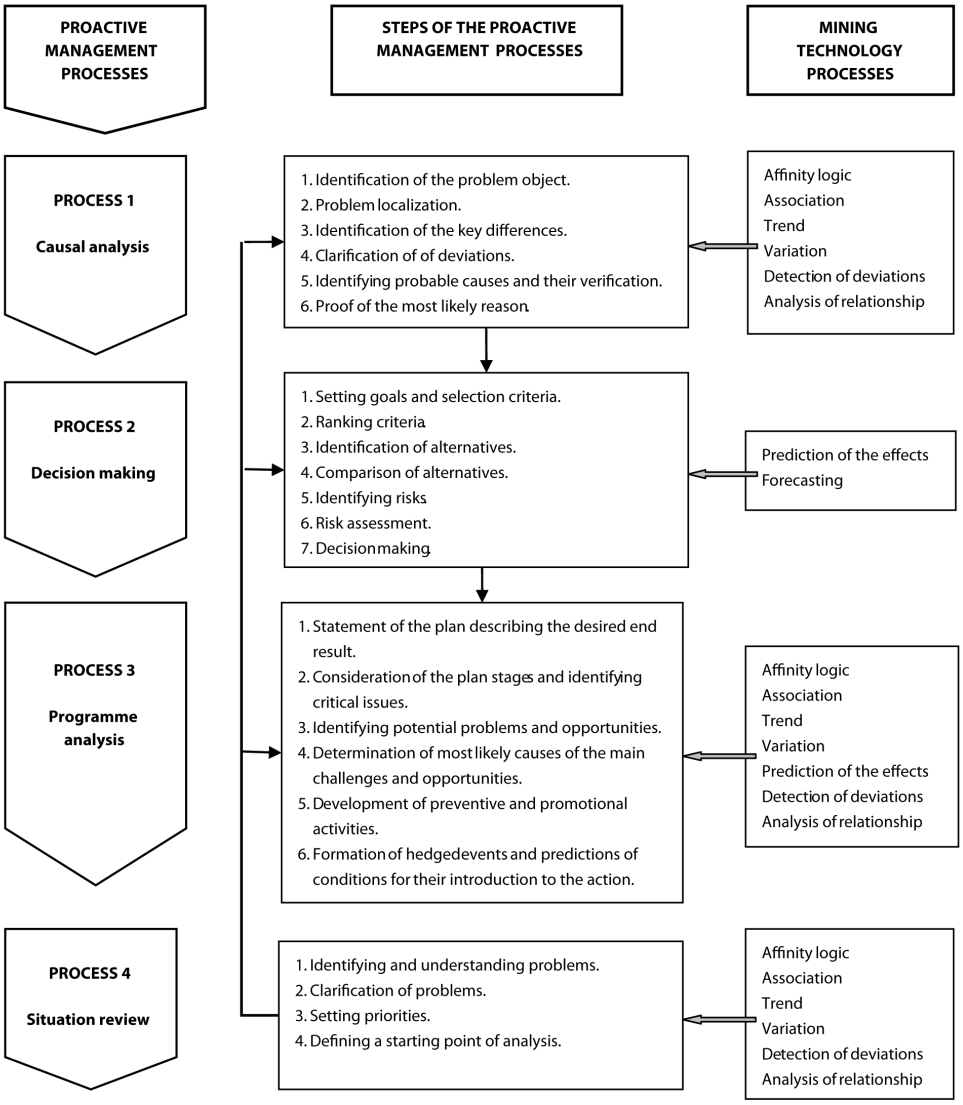

DIAGRAM 2. **Correspondence between the proactive management processes and mining technology processes**

Source: author's own study.

methods, applied statistics, non-numeric statistics, the instruments of fuzzy sets, genetic algorithms, neural networks,etc.

The use of these methods enables:

- to perform monitoring, preparation and data analysis; collection and presentation of data; filtering, grouping and comprehensive data reporting; situation identification;

- to identify problem situations, their patterns; to correlate the pattern of the current situation with patterns of problem situations; to determine the structure of the problem situation; to identify factors and relationships;
- to set the priority on the solution of problems, their importance, periods of solution, trends of problem development and their expected consequences (rank patterns of the situations); to predict the development of situations without and with the managerial influence; to assess the situation according to different criteria;
- to set managerial tasks: to analyse deviations in performance indicators; to define goals, criteria, operating conditions; to identify areas of SES tracking, control points (the tree of directions).

In this case, we are talking about using the following types of models:

- cluster allocation situation models by k-means methods; classification of the patterns using decision trees and neural networks;
- situation identification models by the "nearest neighbour" method, the rules induction method, using neural and causal networks, associations, the limited exhaustion algorithm;
- models of the discovery (mining) patterns by induction of rules, using genetic algorithms, neural networks, software agents, categorized graphs, pictographs;
- the predictive model, which uses the "nearest neighbour" methods, rule induction methods, reasoning with precedents, causal networks, statistical methods, associations, neural networks, decision trees, layered compression;
- optimization models using neural networks, genetic algorithms, decision trees, rules induction method;
- models to identify cause–effect relationships by agents (cross-tab), causal networks, evolutionary programming, statistical methods, sample reduction and marking of data subgroups.

Synthetic methods for the detection of situations in the SES are necessary; they organically include logically constructed, mathematically formalized algorithms that enable an interactive impact of experts, the ability to implement the heuristic procedure (visualization).

Situation review procedures are inextricably linked with a continuous object diagnosis, identification and systematic classification of regular and abnormal situations that are an integral part of the process of knowledge and experience accumulation in the SES. Development of the models and methods that promote an effective implementation of these tasks is one of the stages of control system synthesis for the development and operation of the SES.

Much attention to problem revealing models using the mining technology is given in works related to studying the situation mechanism of management decision-making

(Lepa, 2006). However, most attention is paid there to the methods based on data retention. A significant potential of methods based on the distilled data should be noted.

In finding some problems, two aspects – the urgency and importance – should be considered. Urgent problems require an immediate response and implementing adequate managerial measures, and significant problems need well-planned, long-term management actions.

Problem identification should be accompanied by a list of their sources, causes and options and determination of situation development vectors including and excluding control impacts.

Identifying patterns and relationships between events and phenomena occurring in the SES is a problem which can be solved by studying situation development in the multidimensional space of the parameters that characterize it from different sides. The problem situation has long chains of cause–effect relationships. Its appearance and availability can be investigated by the scheme: the problem (result) – ymptoms (indicators) – parameters – factors – causes – root causes. In order to anticipate a problem and to proactively pursue preventive measures, its root causes need to be known. On the other hand, a problem can be seen as a reason, so in the mechanism of proactive management implemented in a decision-making system of any SES, an essential part should be forecasting situation development in two directions – without management impact and with a managerial influence on the basis of causal relationships among the events.

The process of causal analysis can and should be implemented at all stages of the full cycle of problem solving, but in certain situations its application is self-sufficient to ensure an effective management. This is a situation where from a clear formulation of the problem its apparent resolution is derived, although at first glance the problem and the nature of the reasons that have caused it may be far from obvious.

Problem situation recognition is based on the determination of symptoms – signs of phenomena in the internal and external environment, which is associated with a certain influence on the system, the source of action, factors and causes. However, symptoms often do not work, because the classical methods that are used are no more sensitive to small changes in characteristics or a compensatory influence on each other.

The use of the mining technology methods for the process of causal analysis enables:

- to perform monitoring, preparation and data analysis; collection and presentation of data; filtering, grouping and comprehensive data reporting; localization of the identified causal relationships;
- to identify causal relationships and their patterns; to correlate the identified factors and relationships with the patterns of causal relationships, to determine the structure of a causal relationship;

- to create the causal chain hierarchy – a chain of interrelated causes and effects: to predict the situation without and with managerial influences, to construct sets of situations on the basis of relationship models.

Analyzing the activities of the SES, a situation needs to be modelled in the current time that is taken into account in determining the state of the current system, and aggregate them from the beginning of the reporting or planned period in order to determine first the overall and then the global situation. The final state of the system is defined as a global integral state.

Disclosure of problems allows identifying and formalizing the situation to the level of a particular model in order to make substantial management decisions based on its analysis. At this stage, a particular technology for problem solution is chosen, the situational approach is implemented effectively through the procedure depending on the type of solutions (standard, binary, multivariate or innovative).

The methodical basis for the decision-making process as a proactive management process is the utility theory methods, statistical methods, operation research methods, expert methods, etc. However, it is not always possible to obtain a decision based on the model that contains only quantitative indicators. The exact value of indicators in many cases does not bear any substantial load, otherwise the nature or type of system's behaviour and the expected state are unknown.

The use of MT methods extends the classical approach instruments and makes it possible to define goals and criteria through constructing the sets of targets, ranking the criteria, to use the optimization models based on neural networks, genetic algorithms, decision trees, induction methods, to search for solutions by specific methods.

Highly promising are the hybrid approaches, namely improvement of classical methods by incorporation of mining technology into them. An example could be a mechanism for increasing the objectivity of expert estimations through the use of neural networks in the block of estimate correction, evolutionary modelling of expert estimations (Gnatiyenko, 2008), etc.

The informational basis for defining a set of alternatives and management decision making to break the problem situation is the procedure of identifying problematic situations. Thus, in the system of training and management, decision making is needed to integrate the original and systematic blocks for evaluation of the effect of their implementation on the solution of problem situations. The information for such an assessment should be based on the results of monitoring the implementation of solutions. This allows a real-time monitoring of the performance dynamics and preparation of the decision-making information for additional administrative impacts with adjustment of the way of achieving the planned values of key indicators. Analysis of a systematic evaluation of the management decision feasibility is the basis for updating the knowledge of the SES for solving problem situations within the blocks of situation recognition and decision making.

It is important not only to elucidate the problem and to assess the consequences and risks associated with the implementation of each of the alternatives; the main thing is to focus on the process of the practical implementation of the alternative that has been chosen for solving this problem. It shifts the emphasis from the plan as a set of indicators to be achieved on the programme of actions as a sequence of steps to achieve this final result. In the centre of the programme analysis there are potential problems identified as the negative factors and the possibilities as the positive factors that can be expected during programme implementation. A. detailed development of these aspects of the problem solving and decision-making is one of the most powerful methods of proactive management. Too often the problem is aggravated due to the fact that the SES is not provided with "alarms" that indicate a problem, security measures are not planned in advance, reserve actions for a rapid elimination of unexpected complications are absent, etc.

Identifying the patterns and relationships between events and phenomena occurring in the SES is a complex task which can be solved through an in-depth study of the situation development in the multidimensional space of parameters that determine the need to develop forecasting situation models without and with the managerial influence and scenario analysis. The scenario model of the situation development related to the implementation of the chosen alternative reveals the perspectives of the SES, usually in three versions – pessimistic, realistic and optimistic. The mining technology allows using for this purpose the rule induction instruments, case-based reasoning, statistical methods, associations, neural networks, decision trees.

The control of effectiveness will depend on the ability to focus on several critical areas, to identify the related threats and opportunities, their probable causes and to develop appropriate actions for a successful implementation of the programme.

Model and application levels

The model level of the proactive management decision-making mechanism concept based on mining technology involves a synthesis of situation and relationship identification models, visual electronic models, forecasting models for situations, optimization models of decision making and scenario models of the situation development.

The application level of the proactive management decision-making mechanism concept based on mining technology is defined by formalization of its main methodological and model structures to the level of specific information technologies; their implementation into the SES management practice will improve decision-making accountability and efficiency. In general, the relationship of basic elements of theoretical and methodological, methodological, instrumental, model, organizational and practical levels of the proactive management decision-making mechanism in SES presented as a conceptual scheme (Diagram 3).

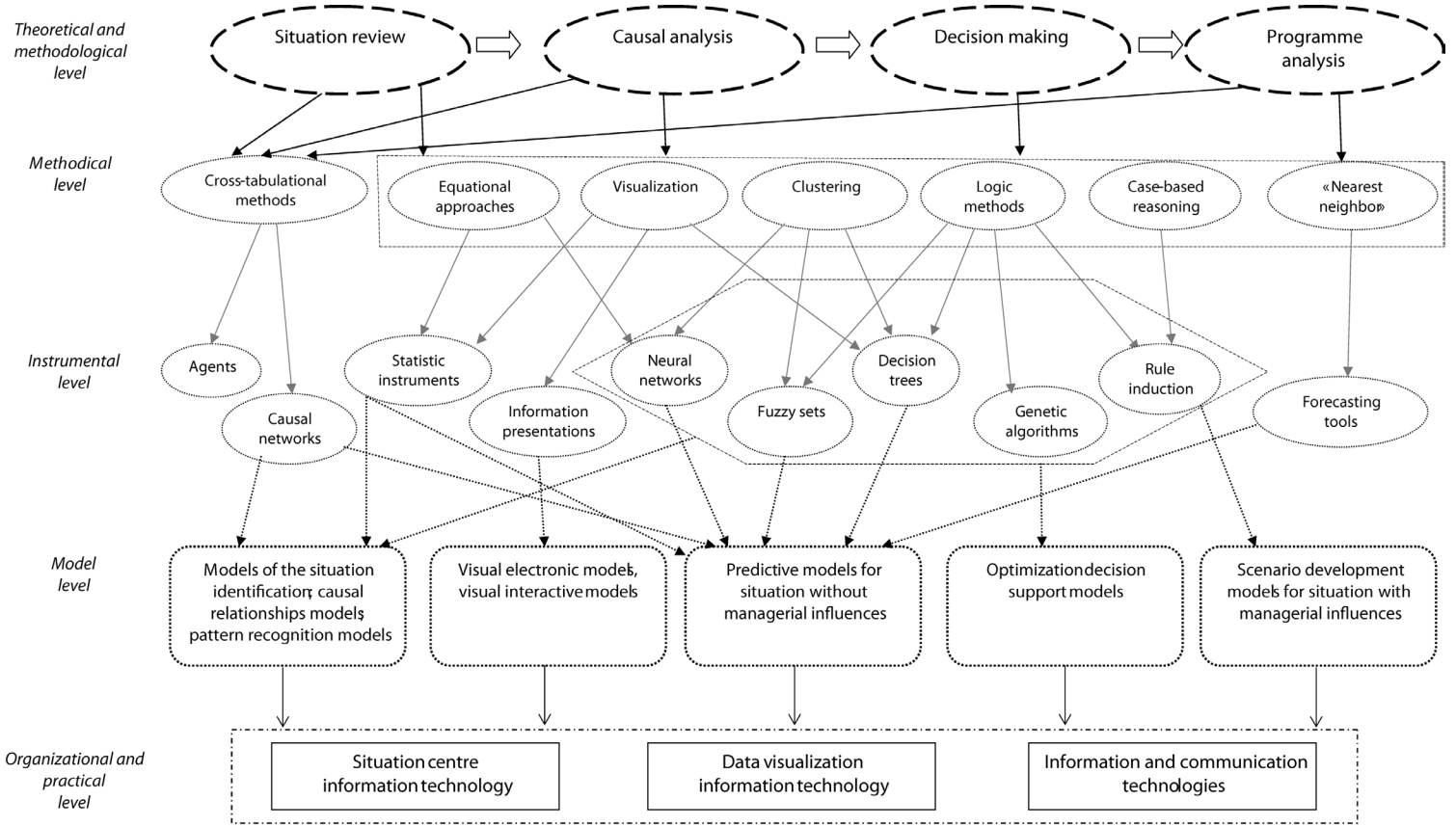

DIAGRAM 3. **Conceptual diagram of the proactive mechanism of decision support based on mining technology**
Source: author's own study.

Computer support of the proactive management decision-making mechanism should be resolved through the distribution of functions between the computer and the manager when the computer is given an auxiliary role, the role of "support", and the main role belongs to man. To provide the most effective assistance of artificial intelligence to managers, information should be submitted in a form suitable for human perception.

Among the facilities offered today by the information technology market for the processing and visualization of data for management decisions, promising are analytical applications and the analytical framework, which are associated with the implementation of Business Intelligence (BI) [Turban, Sharda, 2010]. The appearance of the BI technology gave start to a new generation of information-analytical systems which today include various tools of the mining technology (Table 1).

Of great value for BI implementation is the development of analytical applications presented as a service (Software as a Service, SaaS). The SaaS, Web 2.0 and some other technologies are included into the Cloud Computing Technology. Significant prospects are opened by the development of BI technologies presented in the form of hybrid applications in which the analytics is implemented without a full review of the existing software.

TABLE 1. **The functionality of information systems for mining technology**

Functional components / Companies-producers	Data warehouse	Business analytics	Scorecards	Data mining	Text mining	Decision support	Data integration	ETL-technology
IBM (incl. Cognos, Applix, Celequest, SPSS, DataMirror, Adaytum, Frango, ILog, AptSoft)	x	x	x	x	x	x	x	x
Infor (incl. Epiphany, Extensity, GEAC, MIS)	x	x	x	x		x		
ISoft				x			x	x
Megaputer				x	x			
Microsoft (incl. FRx, ProClarity)	x	x	x	x				x
MicroStrategy	x	x		x		x		
Oracle (incl. Hyperion, BEA, Sunopsis, Haley)	x	x	x	x		x	x	x
RapidMiner				x	x	x		x
SAP (incl. BusinessObjects, Cartesis, Fuzzy, OutlookSoft, Pilot Software, Armstrong Laing, First-Logic, SRC Software)	x	x	x	x	x	x	x	x
SAS (incl. DataFlux)	x	x	x	x	x	x	x	x
StatSoft		x		x	x	x		
Tibco (incl. Insightful, Spotfire)		x		x		x	x	

Source: Bondarenko, Tihonov (2009).

A powerful way to support the proactive management decision-making mechanism can be the situation centres equipped with all necessary multimedia tools that provide a rapid and deep "dive" of the manager in the situation.

The importance in the proactive management decision-making mechanism support should be given to group interaction, i.e. information technologies of collegial decision-making support.

Conclusions and directions for future research

The results of the present research allow formulating a series of conceptual conclusions, namely to substantiate that to solve the tasks of proactive management decision making, the mechanism of mining technology should be involved; to select the basic methods, tools and models for decision support, ways of mechanism implementation through the use of modern BI technologies, development of situation centres technology, collegial approach to decision making. The proposed approach meets the essential qualifications required for management: performance management functions, the presence of feedback, adaptivity.

The problem of identifying proactive management mechanism realization areas is very important, but its solution is likely to rely on the leadership of the SES and its consultants (experts) who need to make a thorough systematic analysis of the structure and activities of the SES associated with a unique decision-making in each individual SES; to set the task of developing a universal set, for example, areas of tracking the situations in isolation from the analysis of specific SES, and to use it as a basis for forming a set of indicators for any SES does not make any sense.

As the prospects for the further research, the realization of the application level concept of proactive management decision-making mechanism based on mining technology for specific types of the SES can be considered.

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