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INTELLIGENT TECHNOLOGIES IN HYBRID CORPORATE DSS (ON THE EXAMPLE OF UKRAINE OIL&GAS PRODUCTION COMPANY)

Abstract

Oil and gas companies in order to maintain their efficiency in the conditions of: liberalization of markets, globalization, increased competition, reduction of consumer loyalty, constant variation in oil and gas prices, further development of Industry 4.0 and the Big Data factor, growing costs for drilling and completion – must have a flexible environment of information technologies that enables seamless and efficient sharing of knowledge throughout the company and along the entire value chain. One of the elements of this task is the effective use of hybrid knowledge-oriented decision support systems (DSS). This, in particular, determines the future stage of complex author's research – the development of a complex perforating knowledge management policy of an oil and gas company, the key tool for the implementation of which will be the hybrid, knowledge-oriented DSS considered in this publication.

The form of knowledge representation has a significant impact on the characteristics and properties of a knowledge-oriented system. Therefore, based on the specifics of the exploration and development of oil and gas fields and the main advantages of the rule-oriented model of the DSS knowledge base, it is possible to conclude that it is necessary to use the KB rule-oriented basis for the DSS of an oil and gas production company. The rule-oriented subsystem is the main one in the knowledge-oriented DSS of an oil and gas production company, in fact, other subsystems provide it with analyses, assessments, and knowledge. Namely, the final product of the system: recommendations for making management decisions is carried out by a rule-oriented subsystem. In general, scientifically based conclusions were obtained regarding the knowledge-oriented architecture of the intellectual DSS of an oil and gas company, the basic model of knowledge presentation (production), the features of the mechanism of logical conclusion (direct logical conclusion), the conflict resolution procedure (a method of ordering products), etc.

In the oil and gas industry, DSS built according to a hybrid approach have the greatest application potential – which are a powerful tool for solving complex specific problems of an oil and gas company. Therefore, in this work, the principles of hybrid application of intelligent technologies and the knowledge-oriented basis of DSS of an oil and gas company were further developed.

Inrtroduction. During the last years, in most countries of Eastern Europe (and Ukraine in particular), even a simple reproduction of onshore hydrocarbon reserves was not ensured. Achieving the possible level of self-sufficiency in fuel and energy resources is a fundamental task of national economies, without which the successful implementation of economic, scientific, technical and social programs aimed at ensuring state independence and stability in Europe is impossible.

However, the onshore oil and gas industry of the countries of Eastern Europe with significant volumes of unexplored oil and gas resources, with the cost of oil and gas several times lower than world prices, the presence of a significant number of oil and gas industries, drilling and geophysical enterprises, oil refineries, and an extensive network of oil and gas pipelines, highly qualified production teams allows, with their effective use, not only to stabilize, but also to significantly increase the production of oil, gas and condensate in the future.

An important reason for the drop in oil and gas production volumes is insufficient management efficiency of the cycle of parallel business processes of the oil and gas company: field exploration, their arrangement and development, production and sale of oil and gas. The solution is the application of effective economic-mathematical modeling at the strategic level of management and the use of knowledge-oriented decision-making support tools as an integral component of the complex information system of an oil and gas company [1].

So, In modern economic conditions (globalization of the economy and simultaneous narrow specialization of economic sectors, the need to take into account when making a decision a huge amount of information from various sources, the need for a quick reaction, changes in the business policy of the corporation in response to rapid changes in the world situation [2]) it is necessary to use AI and a hybrid approach to building knowledge-based IDSS. Moreover, their use is particularly effective in the oil and gas industry of Ukraine, where management decision-making requires complex expert analysis, is associated with significant capital investments, there are many branches of scenarios and decision-making nodes, there are open situations of uncertainty, specific industry risk [3].

1. Knowledge-oriented corporate DSS: modern concept and technology features for current Ukraine conditions

Introduction to the paragraph. Rules-oriented DSS, recommendatory DSS and intelligent DSS are compatible (overlapping) terms of management support systems that are built using artificial intelligence technology. In general, it can be argued that rule-oriented DSS belong to the family of knowledge-oriented DSS.

Knowledge-oriented DSS store and apply knowledge to solve a variety of specific business problems. Knowledge-oriented DSS (including rule-oriented DSS) implement the process of management reasoning in order to respond to an event, using knowledge bases and logical rules to solve a problem situation.

Knowledge-oriented DSS improve consistency in the decision-making process, help to implement business policies and adopt organizational regulations, explain the proposed solutions, which is very important if the staff is inexperienced or resists the proposed solution to the problem.

The concept of rule-oriented DSS. A business rule is a statement that defines or limits some aspect of a business. It is intended to protect the structure of a business or to control or influence the behavior of businessmen. If we decompose some business statement into the most elementary forms, the business rule will be as atomic (indivisible) as possible; but it should still contain enough information to be a coherent complete thought.

Business management operations today are based on thousands of combinations of these rules operating at the operational level in a running business. Business rules define and control all aspects of an organization's products, services, and supporting infrastructure.

Business rules are codified policy and are decision-making practices of the organization. These rules indicate how enterprises "doing business" and in fact they are at the center of the organization and should be treated as assets, the management of which should be given special attention.

The structure of rule-oriented DSS. Rule-oriented DSS have the following structure:

– user interface (the user formulates the problem; the user interacts with the DSS during the logical proof; the user interacts with the system after the logical proof);

– a logical inference machine (software that performs logical reasoning and justification of decisions using sets of stored rules to solve a problem situation.

Functions: uses expert analysis of a problem area stored as rules; can interact with the user to obtain additional information; shows the solution and explains the chain of logical reasoning.)

Properties of the logical inference machine:

1. Conducts a logical inference process with any rule that is created using the rules administrator;

2. Some logical inference machines support a hard-coded user interface, that is, one that is immutable – this gives developers limited control over user interfaces. All created systems have the same interface;

3. A number of logic inference machines integrate a logic inference engine with standard I/O capabilities, such as:

– control over fast positioning;

– use of form-oriented iterations;

– selection of intensity and color;

– customizable menu.

4. The power of DSS depends on the types of rules with which the system can operate:

– a system with low power only deals with elementary rules (5-year-old human brain)

– a high-powered system deals with elementary and complex rules (19-year-old human brain).

5. Types of logical reasoning (considering):

– a direct logical inference

– reverse logical inference

– both (more multilateral)

6. The ability to operate with uncertainty:

– the types of uncertainty to be dealt with;

– control over how uncertainty affects the process of logical reasoning

7. Environment:

– autonomous stand-alone shell: a logical inference machine is an isolated program that is called for execution from the operating system;

– integrated environment: the logical inference machine can be called wherever you want: inside the spreadsheet processing; within the procedural model; in the middle of the word processing process, etc.

– the repository of rules includes:

– the repository administrator (performs the rules administration process, manages author permissions, rules publication, debugging, registration and version control; supervises the management of working groups);

– the author of the rules (manages the process of development, establishment and maintenance of business rules within the framework of the business policy model);

– the rules server (calculates rules using actual data from the database within the existing business policy model according to the given conditions);

– set of rules.

– database (contains a set of factual data about business objects and business processes of a specific subject area).

There is the following order of interaction between the components of rule-oriented DSS when forming a response to a given problem situation: database → rules store → logical inference machine → user interface.

Structure and types of rules. It should be noted that the rules inform the inference machine what to do when a certain situation occurs.

There are two necessary components: a prerequisite (one or more conditions); an inference/output (one or more actions) interacting according to the scheme.

Types of rules:

– a simple rule

Rule 1: (one condition → one action):

– rules using logical operators

Rule 2: (two conditions → one action):

(conjunction: both conditions must be met for the premise to be true)

Rule 3: (three conditions → two actions):

Rule 4: (one or more conditions → one action):

(disjunction: if either of the two conditions is true, then the conclusion is true)

Rule 5: (one or many conditions → an action):

(the conclusion is true if one, but not both, conditions are true)

Rule 6: use of negation in a condition: (A condition or several conditions are not fulfilled → an action)

– rules for using input actions:

All the examples described above have only one type of action – it is assigned actions, another type of action – is data input.

Rule 7: (multiple conditions → data entry)

Logical reasoning (considering) using rules. Logical proof (considering) includes:

– the ability to choose appropriate rules;

– the ability to determine whether the prerequisite is satisfied;

– the ability to carry out certain actions (which are also called "activation of the rule");

– the ability to acquire additional knowledge, if necessary.

Handling unknown variables. Unknowns are potentially known if the value of the variable is unknown, but can become known in the process of proof (logical activity).

Procedure for dealing with/ handling unknown variables:

– the value of all variables is still unknown;

– while the logical inference mechanism makes determinations, all known function values are still unknown (not false!);

– the rule cannot be activated, due to the fact that all conditions are unknown;

– conditional solution – asks the user to provide unknown information (this is not always appropriate, because the user may not know the answer, or his answer may be incorrect).

There are 3 main ways to implement a user request regarding an unknown variable:

– building a separate rule that implements the request if the variable is not known (this method involves a large number of additional rules, so processing is slower);

– through the description of a variable as a component part of a set of rules, a request to the user is implemented in this description (it does not require additional costs for the execution of the request, since it is not a rule);

– through the initialization of a series of actions of the mechanism of logical inference, as soon as the user consults the system.

Other sources of values for unknown variables: the user should not always consult an expert, but should, as much as possible, try to discover the answers by himself with the help of other sources chosen at his own discretion, for example:

– reading the text stream of data;
– calculations;
– analysis using a procedural model;
– selective calculations of necessary statistics;
– searching for values in the database;
– a consultation with other experts;
– other.

It is advisable that the rule-oriented DSS supports access to external data files or programs, has access to data that is the result of the execution of external programs or may be under the execution of external programs.

A direct logical inference. Each rule is examined in the forward direction – that is, the premise is examined first.

There are two possibilities here:

– if the premise of the rule is correct, the rule is activated. If false, another rule is considered. If the premise of the rule is false, then it can be revised later. It is possible that working with another rule can change the variables of the previous rule so that the premise becomes correct;

– the premise of the rule may be unknown (neither correct nor incorrect), because the variables in the premise are not known yet. Again, the rule is not activated and another rule is considered. Perhaps the activation of other rules will force the premise to become correct.

There is an initialization order of logical proof (starts execution of the program, usually sets the values of the initial variables) and a completion order (after the program has reached its inference, the result must be displayed to the user through the completion order).

In order of completion, both the traditional instrumentality (provides a report of the value of the target variable to the user, gives limited control over the form of this report) and the advanced instrumentality (more flexible, it can store the found result in the database; use the results as input for other analysis; use the results as a basis for graphics or output to spreadsheets; combine the results in text form with their description; communicate the results to other parties, etc.

Inverse logical inference. Each rule is considered in reverse – the inference is considered first (this method is much more focused than direct logical inference).

Direct logical inference is a "blind" approach.

Inverse logic inference is much more complex and directed approach.

The course of the reverse logical inference:

1. At the beginning, the current variable is a variable representing the general purpose of the study and its value is unknown.

2. The logical inference mechanism searches among the inferences from the rules of the rule set and determines those rules that can possibly set the value of the current variable. These rules are called "candidate rules".

3. The logical inference mechanism selects a rule from candidate rules and examines its prerequisites.

4. If the premise is correct, the rule is activated and the value for the current target is set.

5. Other candidate rules are treated in the same way (they may also affect the value of the current target).

6. If the premise is false, the candidate rule is ignored and the following rule is considered.

7. If the premise is unknown, the logical inference mechanism tries to make it known (by determining the values of the variables in the premise).

There are two ways to do this:

– performs actions on the description of the variable;

– if the description does not exist, then the variable becomes the new current target.

8. Steps 2 to 7 are repeated for the new current target.

There are two possibilities at this point:

a) if achieving the goal does not result in determining the truth or falsity of the premise, then the other unknown variable of the premise becomes the new current goal and steps 2 through 7 are repeated. If there are no more unknown variables in the premise, then the rule is abandoned and returned to the last unresolved goal.

b) if the resolution of the past goal results in the determination of the truth or falsity of the premise:

– if the prerequisite is correct, the rule is activated and another rule – the candidate rule is selected;

– if the precondition is false, the rule is not activated and another candidate rule is selected for the current goal;

– if there are no more candidate rules, then further solution of the current problem is not possible;

– if this is a complete goal, then the logical inference mechanism operates further with the completed sequence;

– if this is not a complete goal, but a sub-goal of the research, then the logical inference mechanism concentrates on another sub-problem that has not been solved yet.

When all relevant sub-problems are resolved, the overall goal will become the current research objective again. If the variable of the overall goal of the study has an unknown value as its result, it means that the set of rules does not have enough expert evaluations to solve the problem.

Intermediate conclusions. Therefore, taking the above into account, it can be outlined the main advantages of rule-oriented DSS: the explanation of the proposed solution; the speed and timeliness of decision support; the ability to do without an expert; managing processing of uncertainty; formalization of expert assessments; the possibility of business policy evolution; the absence of contradictions and the influence of subjective factors, etc.

So, in modern economic conditions (globalization of the economy and simultaneous narrow specialization of economic sectors, the need to take into account a huge amount of information from various sources when making a decision, the need for a quick reaction, changes in the business policy of the corporation as a reaction to rapid changes in the world situation) it is necessary to use rule-oriented DSS.

It should be noted, that their use is especially effective in those sectors of the economy where management decision-making requires complex expert analysis, is associated with significant capital investments. Where there are many branches of scenarios and decision-making nodes, there are open situations of uncertainty, specific industry risk (for example, in the oil and gas industry).

2. Artificial intelligence, Data Science technologies and Fuzzy Logic as part of rules-oriented DSS

Introduction to the paragraph. Maximum supply of Ukraine with its own fuel and energy resources is a fundamental task of the Ukrainian economy. The main factor in increasing domestic oil and gas production is improving the efficiency of knowledge management using artificial intelligence technologies, data mining methods etc.

Application of knowledge-oriented intelligent decision-making support systems (IDSS) as a key tool of knowledge management policy will enable effective management of a complex of integrated processes of an oil and gas production company: exploration and calculation of reserves; development; extraction; marketing; placement of infrastructure and disposal of oil and gas.

Since the birth of computer technology, they have been trying to use it to solve increasingly complex problems. Today, the most developed solution methods are based on formalized algorithms. However, in modern practical activities, most of the actual tasks that require automation are poorly formalized (uncertainty of input information and/or consequences of actions).

The following features of non-formalizable problems are distinguished: the algorithm for solving the problem is unknown or cannot be used due to limited computer resources; the task cannot be defined in numerical form; the objectives of the problem cannot be expressed in terms of a precisely defined objective function.

The birth of the science of artificial intelligence (AI) and the impossibility of solving non-formalized problems by classical methods of management theory, by optimization and system analysis are due to several factors:

– any designer of complex information systems faces with a set of problems that cannot be solved by traditional methods (due to incomplete knowledge about the environment, inevitable errors, unpredictability of real situations).

Which requires the use of adaptive intelligent systems that are able to adapt to changes in the "rules of the game" and navigate independently in difficult conditions;

– the designer cannot take into account and combine the entire set of external conditions into a general system of equations – especially when there are many active players. The "curse of dimensionality" becomes a real limiting factor when solving many complex problems. Therefore, self-adaptation of the system in the process of dynamic modeling in "close to combat conditions" is almost the only way to solve problems in such cases.

Two main approaches are traditionally used to solve non-formalizable and difficult-to-formalize problems:

– rule-based, characteristic of expert systems. It is based on the description of the subject area in the form of a set of rules "if...., then...." and rules of inference. In this case, the sought-after knowledge is represented by a theorem, the truth of which is proven by building a chain of conclusions. With this approach, however, it is necessary to know in advance the entire set of regularities describing the subject area;

– case-based (based on examples), when it is only necessary to have a sufficient number of examples to configure the adaptive system with a given degree of reliability. Neural networks are a classic example of such approach.

In the practice of the development of informatics, there is only one category of information in which the principles of the absence of errors, modernization and development, mobility, etc. are originally laid down – it is knowledge. In general, knowledge which used in artificial intelligence systems usually understood as data, concepts, and information organized in a special way, forming a knowledge base. According to the common definition – this is information that reflects patterns that exist in the subject area and allows to derive new facts that occur in a given state of the problem environment, but are not recorded in the database, as well as to predict potentially possible states.

As stated above, one of the two approaches to solving non-formalized problems consists in the selection of knowledge and the creation of a knowledge base (KB). The knowledge stored in the KB is stored in a specific standard form, which makes it possible to easily define, modify and supplement it.

The knowledge of an expert and a **knowledge-based decision support system** (KBDSS) belongs to a specific subject area. And knowledge about solving certain specific problems is called a field of knowledge. The field of knowledge is fully included in the subject area. And the space between the field of knowledge and the subject area symbolizes that the KBDSS or expert does not have complete knowledge of all the problems of a certain subject area.

The KB should contain knowledge of: the first-class (well-known facts, phenomena that are recognized and published); the second kind (a set of empirical rules and intuitive conclusions that are guided by specialists in conditions of uncertainty and incomplete information, usually not published). The KB mainly contains knowledge of the 1st kind, but there should also be knowledge of the 2nd kind, if they are absent, then this means a bad choice of experts who do not know how to formulate their acquired heuristics or do not want to share them. In addition, knowledge is divided into: facts; rules; meta data (knowledge about knowledge). Knowledge in the KB is also divided into: intentional (abstract); – conceptual knowledge about the objects of the subject area and the connections between them; extensional (specific) – quantitative characteristics of intentional knowledge, i.e. database. The following classification of knowledge by representation is distinguished:

– declarative knowledge (facts, i.e. classes of objects and the relationships/interactions between them. Software modeling requires a complete description of all possible states of the software. Solving the problem in this case is based on searching the set of possible states of the software);

– procedural knowledge or rules (a set of certain procedures for transforming knowledge as data. There is no need to store information about all possible states of the subject area, it is enough only to have a description of the initial state and procedures that generate all the necessary states based on the initial state).

The form of knowledge representation has a significant impact on the characteristics and properties of the system. The presentation of knowledge should be uniform, understandable to both experts and system users.

There are 4 models of knowledge representation:

– a logical model (knowledge is presented in a system of predicate logic of the first order. The advantages are: the unity of the theoretical justification and the possibility of implementing a system of formally precise definitions and conclusions. However, when solving complex problems, it is very difficult to express heuristics in a system of clear logic. Therefore, the main achievements in the theory of KB associated with the use of illogical models of knowledge representation);

– a production model (based on the use of "If-Then" type rules. The advantages are: ease of creation and understanding of individual rules; ease of addition and modification; simplicity of the mechanism of logical inference. Disadvantages are: ambiguity of relationships between rules; complexity of evaluating a holistic image of knowledge; low processing efficiency; difference from human knowledge structure; lack of flexibility of logical inference. The conflict resolution procedure and information about the sequence of use of production rules are the core of the production system management strategy. There are a number of techniques for selecting the desired rule from the conflict set: ordering of products (the sequence of use of rules is indicated); setting parameters indicating the age of the data (first of all, the rules that are the most "fresh" are activated); first of all, the use of rules with the largest list of conditions);

– a frame model (the model of human memory and consciousness. It is based on the concept of a frame – a data structure for representing some conceptual object. It has wide possibilities and flexibility.);

– a model of a semantic network (that is, a system of knowledge that makes sense in the form of a holistic image of a network, the nodes of which correspond to concepts and objects, and the arcs correspond to relations between objects. One of the limitations of the semantic network is the inability to clearly imagine a wide range of conditions that is easy to represent by production rules. To eliminate this, an independent structurally inherited network is used, which combines the advantages of semantic networks and production rules.).

Concluding the consideration of the means of presenting knowledge about the world, it is worth noting that, in general, none of them has such advantages that would allow us to completely ignore the others. **The choice of one or another means largely depends on the specific subject area of the problems to be solved, as well as other factors.**

The maximum effect in the organization of knowledge-oriented decision-making processes can be obtained with a flexible and mobile IDSS, which allows the maximum combination of procedural devices of various management methods and flexible restructuring to new types of information base when decision-making methods are changed. In this direction, there is an indisputable advantage of DSS, which are based on flexible methods of representation and processing of economic information, that is, information systems using the concepts of knowledge bases. Orientation to knowledge provides a double advantage: firstly – the flexibility, meaningfulness and expressiveness of knowledge in the representation of a complex and unstructured system; secondly – the mobility and correctness of the KB when transitioning to new decision-making methods and the need to adapt to new conditions.

Based on the specifics of oil and gas exploration and development activities and the main advantages of the rule-oriented model of the ISPPR knowledge base (explanation of the proposed solution; speed and timeliness of the decision support; dismissal of a human expert; uncertainty management; formalization of expert assessments; the possibility of business policy evolution; lack of contradictions and the influence of a subjective factor, etc.) it is possible to conclude about *the need to use a rule-oriented basis of the KB for the IDSS of an oil and gas production company.*

A knowledge-oriented intelligent decision-making support system is a DSS, which is built using artificial intelligence (AI) technology, uses knowledge-oriented technologies of expert systems (ES) and knowledge extraction tools, and is the most progressive direction of the development of DSS. The concept of IDSS includes tools for data mining. Using AI and statistical analysis, these tools find new information in existing data. In addition, the system determines how to display the acquired knowledge so that it is understandable to people. Other IDSS use embedded neural networks that learn from examples to recognize models/patterns and deviations from them.

It should be noted that the choice of the most correct direction among the trio of AI, ES and DSS is not promising, since it is difficult to find a clear line of distribution, depth of intersection and entry into each other. *It is necessary to combine all three concepts, which ultimately enriches the concept of intellectual DSS.* IDSS know how to operate with incomplete or doubtful information, qualitative logical connections, give explanations of results, solve problems of evaluating a huge number of alternatives and their classes, which is typical for an oil and gas company.

It is AI technologies that enable IDSS to solve unstructured, poorly structured or semi-formalized classes of tasks of the company's top management. Therefore, the current trend is to include AI and ES in the IDSS. In a review of the US Department of Commerce for recent years it is noted that 70% of the largest 500 American companies use AI in one way or another in their operations.

AI technology is used in the DSS to help with the following questions: which data to choose for analysis or how to analyze it; performing a sensitivity analysis (to be sure that all aspects of the problem are considered); identification of already studied aspects of the problem and correlation of current findings with past analyzes and data.

AI technology is associated with problems that require expert expertise, where an expert is not always available or his services are expensive, where decisions must be made quickly, where there are too many alternatives to consider at the same time, and where the cost of error is very high. AI also helps in situations where the stability and reliability of knowledge-based technology's judgments are the main goals, rather than creativity in the decision-making process.

AI plays two roles in DSS. Firstly, AI can serve as a type of model, that is, a heuristic modeling technique that manipulates primarily symbolic information. This type of modeling reproduces the human reasoning process, which is especially useful when solving vague problems or under conditions of incomplete information. The second way of using AI technology in the DSS is providing intelligent support to users. With the use of AI technology, DSS developers can incorporate the technology of using human expertise into modeling processes, evaluation of alternatives or final analysis to improve the quality of decisions of all DSS users. Developers must codify the knowledge of experts, build procedures for processing this information, and establish the way in which the uncertainty of information and relationships will be handled

Today, the greatest potential and hopes are placed on *hybrid IDSS*, which are a powerful tool for solving complex problems that are beyond the power of "pure" approaches. For example, combining the paradigms of using rules and precedents allows to improve the efficiency of exception handling without complicating the set of rules. Thus, each of the components deals with what it is best focused on: rules deal with generalizations of the subject area, and precedents with individual atypical cases. This approach requires that the database of precedents should be indexed according to the applicable rules. Let's consider a hybrid combination of ES technologies and neural networks in IDSS. Collecting and storing expert knowledge is best done by ES, but they do not adapt to changes immediately.

Neural networks, on the other hand, are not very good retainers of expertise, but they can be trained to extend learning. Neural networks can look through large amounts of data and find causal relationships that help them to adapt to changes in their environment. Together, the two technologies can provide full-fledged support within the framework of the DSS.

The combined use of the expert system and the apparatus of artificial neural networks provides the necessary flexibility and self-learning based on knowledge. At the same time, the knowledge obtained from experts allows to simplify the structure of neural networks significantly, to reduce the number of neurons and network connections. The neural network approach is particularly effective in expert assessment tasks because it combines the computer's ability to process numbers and the brain's ability to generalize and recognize (for example, this approach should be used in the tasks of assessing the assets of oil and gas companies).

An important issue is the handling of uncertainty in the decision making process, therefore, the intellectual DSS should be capable of uncertainty management, namely: uncertainty regarding external objects that will affect the success of the decisions made; uncertainty regarding the reliability of information used as a basis for decisions; uncertainty about the validity of the relationships that determine the choice situation. Also, the uncertainty that arises in the process of making management decisions is divided into: insufficient complete knowledge of the subject area; insufficient information about a specific situation. Inexact methods are used by experts, and therefore are oriented towards the knowledge of IDSS, for several reasons: if accurate methods do not exist; if accurate methods exist, but cannot be applied in practice due to the lack of the necessary volume of data or the impossibility of their accumulation (due to high cost, risk or lack of time to collect the necessary information).

There are 3 main approaches to dealing with uncertainty in intelligent systems: probability theory, confidence factors, and fuzzy sets. The following arguments are put against the use of probability theory: probability theory does not provide the answer to the question of how to combine probabilities with quantitative data; assigning the probability to certain events requires information that OPRs simply do not have; updating the probability estimates is very expensive as it requires a large amount of computation and so on. However, the result of using fuzzy sets is often far from ideal. Studies have shown that methods based on fuzzy logic are less reliable than Bayesian methods. However, since the goal of the research is knowledge-oriented DSS, it should be taken into account that it is not natural for a person to make judgments based on the Bayesian approach. The advantages of fuzzy logic for designers of knowledge-based systems lies in its closeness to natural language. This simplifies the knowledge engineering process. So, knowledge-oriented IDSS for the oil and gas industry should use fuzzy logic.

This term does not mean a disordered thought process, but means operating with imprecise data and relationships. People use fuzzy logic regularly, each time, when a solution does not have "white" and "black" solutions.

Fuzziness provides flexibility in the approaches to problem solving, forcing us to consider all possible options. An illustration of this is that humans can make better decisions than computers by using uncertainty in their inferences. Fuzzy sets should be used when building the most realistic system models.

Similar to the technology of neural networks and systems using fuzzy logic, knowledge-oriented technology also has the ability to learn, that is, to improve the characteristics of the system by improving the structure and increasing the knowledge base. It should be noted that, unlike neural networks, ES technology cannot generalize situations by parameters and criteria for choosing actions yet, but only compares a set of values with a database of precedents.

The implementation of generalizations in knowledge-oriented systems is possible when using a hybrid approach to the construction of knowledge-oriented IDSS (use of elements of fuzzy sets, neural networks, etc.).

Intermediate conclusions. It can be argued that in modern economic conditions (globalization of the economy and simultaneous narrow specialization of economic sectors, the need to take into account when making a decision a huge amount of information from various sources, the need for a quick reaction, changes in the business policy of the corporation in response to rapid changes in the world situation) *it is necessary to use AI and a hybrid approach to building knowledge-based IDSS. Moreover, their use is particularly effective in the oil and gas industry of Ukraine*, where management decision-making requires complex expert analysis, is associated with significant capital investments, there are many branches of scenarios and decision-making nodes, there are open situations of uncertainty, specific industry risk.

Conclusions. The oil and gas producrion industry of Ukraine is in a difficult state today, which is caused by a number of military and economic factors. All these factors in one way or another are reinforced by the lack or absence of information regarding the main production and economic processes and its low efficiency, the lack of perfect means for comprehensive analysis and forecasting, and the insufficient functionality of existing information systems. However, it is necessary to note the lack of a strategy and complex approach to complex automation, insufficient attention to the use of network technologies, the introduction of modern innovative information technologies and algorithms, in particular (AI, Data Science, Big Data, etc.). Thus, the absence of a balanced innovative automation strategy of an oil and gas company has the greatest negative impact on the strategic level of the company's management, where the cost of a manager's error is the greatest. It is possible to conclude about the importance of creating an information system of an oil and gas company, the result of which will be increasing in the efficiency (improvement of quality and efficiency) of a management of a complex of business processes of an oil and gas production enterprise, and as a result – an increase in the market value of the company.

Oil and gas companies will be able to operate around their core business – analysis and interpretation of exploration and development data, and transfer all related activities to subcontractors, including data management and storage. Through innovations in knowledge management and the corresponding change in business models, oil and gas companies of the future will be more profitable.

The form of knowledge representation has a significant impact on the characteristics and properties of a knowledge-oriented system. The presentation of knowledge should be uniform, understandable to both experts and system users. The choice of one or another means of presenting knowledge largely depends on the specific subject area of the problems to be solved, as well as other factors. For the DSS of an oil and gas production company, a production model of knowledge representation is proposed as a base.

The maximum effect in the organization of knowledge-oriented management decision-making processes in the oil and gas industry can be obtained with a flexible and mobile DSS, which allows the maximum combination of procedural devices of various economic and mathematical models, decision-making and management support methods, and flexible restructuring to new types of information base at changed decision-making methods. DSS, which are based on flexible methods of presentation and processing of economic information, that is, information systems using the concepts of knowledge bases, have an undeniable advantage in this direction. Orientation to knowledge provides a double advantage: firstly, flexibility, meaningfulness and expressiveness of knowledge in the representation of a complex and unstructured system; secondly – the mobility and correctness of KB when transitioning to new DS methods and the need to adapt to new conditions. In this way, knowledge-oriented DSS improve consistency in the decision-making process, help to implement business policies and adopted organizational regulations, explain the proposed solutions, which is very important if the staff is inexperienced or resists the proposed solution to the problem. The nature of human expertise includes the ability to find high-priority problems, explain results, learn from mistakes, if necessary, restructure the relevant knowledge, take into account common sense, sometimes break the rules and the property of gradual temporal degradation of the quality of the decision made. No existing technology can satisfy all these requirements, and the way out is the further improvement and development of AI family technologies as a component of DSS.

Based on the specifics of the exploration and development of oil and gas fields and the main advantages of the rule-oriented model of the IDSS knowledge base, it is possible to conclude that it is necessary to use the KB rule-oriented basis for the IDSS of an oil and gas production company. Having analyzed the advantages and disadvantages of the two main types of logical inference and based on the above study of the properties of economic and mathematical models used in the decision-making processes of an oil and gas company, a direct logical inference was chosen for implementation in the knowledge-oriented DSS of an oil and gas company. In addition, the conflict resolution procedure and information about the sequence of use of product rules is a component of the rule-oriented DSS management strategy, and its study is important in the construction of the oil and gas company's rule-oriented DSS technology.

The rule-oriented subsystem is the main one in the knowledge-oriented IDSS of an oil and gas production company, in fact, other subsystems provide it with analyses, assessments, and knowledge. Namely, the final product of the system: recommendations for making managerial decisions are carried out by a rule-oriented subsystem.

Today, hybrid IDSSs have the greatest potential, which are a powerful tool for solving complex problems of an oil and gas company. In particular, combining the paradigms of using rules and precedents allows to increase the efficiency of exception handling without complicating the set of rules; a vague logical conclusion allows to take into account uncertainty (which is inherent in problematic situations in the oil and gas industry) when making decisions; the combined use of the expert system and the apparatus of artificial neural networks provides the necessary flexibility and self-learning based on knowledge, at the same time, the knowledge obtained from experts allows to significantly simplify the structure of neural networks, reduce the number of neurons and network connections; using fuzzy logic to determine which input parameters are most correlated with target variables; the use of genetic algorithm technology to select inputs for the neural network in the form of natural selection and training of the neural network by selecting adequate parameters; the combined use of the concepts of neural networks and fuzzy logic is a promising direction (the use of fuzzy neural networks, in which conclusions are made on the basis of a fuzzy logic apparatus, but the corresponding membership functions are adjusted using neural network learning algorithms, as this makes it possible to acquire new knowledge and achieve logical transparency).

An important issue is the consideration of uncertainty in decision-making support processes, therefore, an intelligent DSS should be able to handle uncertainty. If we want to assess the risk associated with a typical phenomenon, then we use a probabilistic approach, and in the case of assessing a specific unique object (which is typical for the oil and gas industry), we use a fuzzy approach. It is worth using the considered technology of fuzzy logical conclusion in the following cases: if expert knowledge can be formulated mainly in linguistic form; for complex processes in the absence of a simple mathematical model. Based on the conducted research, it was concluded that the following combination of components of the algorithm of fuzzy logical inference is a universal approximator and is recommended for use in the subject area that is under consideration: Gaussian membership functions, composition using the product, implication according to the Larsen algorithm, and the centroid method of defuzzification.

Liberalization of markets, globalization, increased competition, decreasing consumer loyalty, constant variation in oil and gas prices, the development of the Internet and mobile technologies, the growing costs of drilling and completion are forcing and at the same time enabling energy companies in all energy sectors around the world to restructure and radically change the way we do business, focusing on information management and cost control. To be effective and successful in such a demanding business environment, oil and gas companies must have an open information technology environment that enables seamless and efficient knowledge sharing across a company and value chain. New, knowledge-oriented information technology architectures are necessary to maintain and increase profitability, the level of which will no longer critically depend on the level of oil or gas prices.

The ability of a management of a domestic oil and gas company to collect, distribute and use the distributed knowledge of the company makes it possible to develop and implement processes and technologies that will improve the productivity of an oil and gas company and reduce its costs. It is precisely because of the above-mentioned factors an important factor in the increase of hydrocarbon production in Ukraine is the increase in the efficiency of knowledge management through the use of knowledge-oriented technology with elements of artificial intelligence. The application of knowledge-oriented decision support systems as a key tool of the knowledge management policy will make it possible to effectively manage a complex of integrated processes of an oil and gas production company.

Another critical area for today's oil and gas production company is the use of knowledge-based IDSS in the training of an oil and gas field exploration and development specialists. It is necessary to begin now to find and collect the intellectual capital that will leave the industry, and to build solution simulators based on IDSS knowledge, able to condense this knowledge and transfer it more effectively to the next generation of workers. Those oil and gas companies that take care of this in advance will be able to overcome crisis situations more effectively in the future and increase oil and gas production in Ukraine.

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