Intelligent Software Platform and End-point Software for Risk Management

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***Abstract*— The article proposes the structure of an intelligent software platform for managing complex risks. It is proposed to divide the platform into a global and local part (end-point software) that provides not only the management of complex risks on the scale of a single system (enterprise, organization) but also the collection, accumulation, synthesis and dissemination of methods and models of integrated risk management that are best practices that have proven effective on practice. Within the local part, the platform provides the ability to build complexes of hybrid intelligent models by a risk management specialist without the participation of a programmer. Examples of using the proposed solution or its parts in projects aimed at risk management are considered.**

***Keywords*— software for managing complex risks; a global software platform; the dissemination of knowledge**

I. Introduction

In the modern world, open system development tendencies are stronger than ever. Increasing capabilities of global networks in terms of the traffic volume and speed of its transmission ensures rapid accumulation and dissemination of best practices. A good example of such practices is dissemination of car dash camera records. Watched and analyzed, compilations of such records allow drivers to draw conclusions about best practices of behavior in emergency situations while driving. It is the approach of gratuitous dissemination and accumulation of best practices that is most promising in terms of risk management.

A number of advantages are obvious related to risk management:

1) as a rule, occurrence of a risk event or, in particular, some risk situation as a complex combination of risk events [1] is a rarity even for large systems, and the number of risk events with specific and rare equipment, such as oil refineries or gasholders, through the whole history of observations is probably a single digit even within the framework of branch makers;

2) generalization of the acquired experience on a larger scale can provide sufficient knowledge for analysis through methods that involve work with inaccurate, uncertain and fuzzy data, for example, [2, 3] and many others.

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However, application of such methods requires an integrated global system that combines functions of data collection, generalization, accumulation of knowledge and its further dissemination. A global knowledge base should be the basis of such a system.

II. A Global Knowledge Base for Managing Complex Risks

According to [4], knowledge is divided into facts and rules. In terms of working with facts, the tasks of the global knowledge base should be:

1) collection of data on risk events and risk situations that have occurred in a formalized form;
2) generalization and analysis of such data;
3) assessment of data validity and its transformation into knowledge;
4) collection of data on risk management measures;
5) assessment of efficiency of such measures;
6) generalization of knowledge of best practices.

To determine the scheme of work of the global knowledge base with rules, it is first necessary to describe the structure of the rules. We will not consider the rules individually (as we could consider fuzzy productions [5], for example), but in aggregate. The aggregate of rules will be presented by a separate intelligent mathematical model (supporting work with inaccurate, fuzzy and uncertain data). In order for the model to disseminate, we will single out the rules that form the model or facts within the rules, as well as some procedures that allow us to "animate" this model on the basis of such facts. Thus, the rules in the store have the following structure:

1) facts that determine the settings of rules;
2) rules for constructing intelligent models based on facts designed to construct models;
3) rules for application of intelligent models based on facts intended for application of models.

In terms of risk management, the facts for constructing and applying models have the same structure, presented in [6] in the form of a graphical notation. For storing and transmitting such information a universal format of data storage and transmission can be used [7], which ensures filling the store

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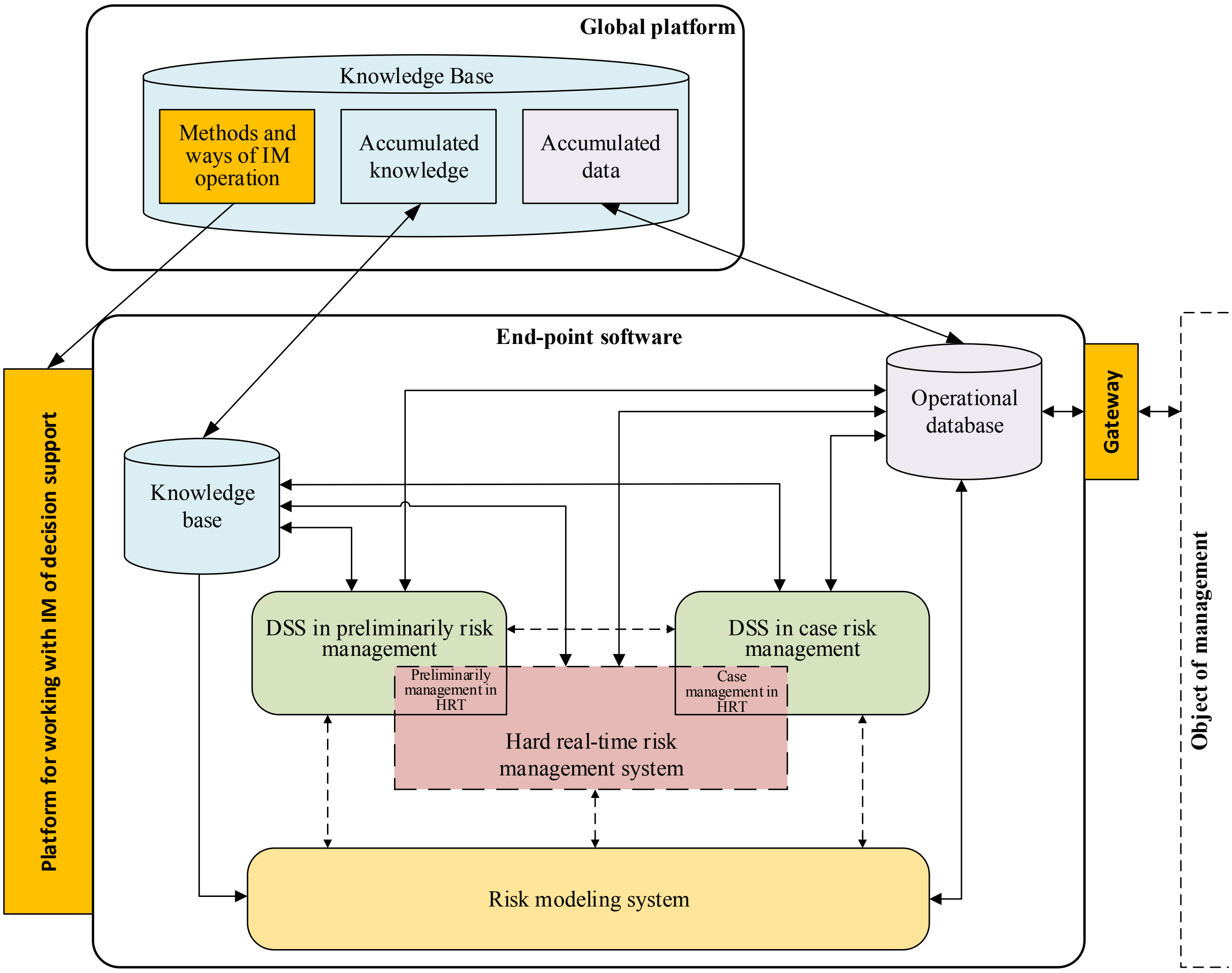

Fig. 1. Structure of the intelligent software platform for complex risk management

both with facts for model construction and with facts for model application.

For dissemination of best practices in the form of models, a unified format for interaction of such models and an interface (in the sense of object-oriented programming) of their implementation must be defined. As the format for dissemination of rules of model construction and application the format of dll-libraries can be chosen. This matter will be considered separately.

III. Intelligent Software Platform for Managing Complex Risks

The availability of the above-mentioned method of transferring knowledge in the field of risk management, the need to divide risk management into preliminary and case management[1], as well as the existence of a cognitive gap that does not allow users to develop intelligent systems, and programmers to work out the developed systems in detail required by the end user, determine the necessity and possibility of creating an intelligent software platform for managing complex risks. Figure 1 presents the structure of such a platform.

In general, the platform is divided into 2 components.

1) A global part, which is a knowledge base in the field of risk management.

2) An end-point solution used to manage on-site risks.

The local solution is based on a platform for working with intelligent decision support models. Such a platform meets the following requirements:

- it should be the core ensuring the launch of intelligent models derived from the global part of the platform;
- it should allow to arrange intelligent models into cascades of arbitrary complexity, to hybridize intelligent models without a programmer.

The local solution itself has the following basic elements:

- decision support system (DSS) for preliminary risk management;
- DSS for case risk management;
- hard real-time risk management system;
- risk modeling system;

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- knowledge base;
- data base.

A. Decision support system

DSSs for preliminary and case risk management implement functions of prior and subsequent risk management respectively in accordance with the approach proposed in [1]. In this case, in accordance with the approach, each system should have 2 components: a hard real-time system [8], [9] and a non-time-critical system (planning system).

Before the occurrence of an undesirable event (risk implementation), one can try to create conditions preventing the occurrence of such an event. As a rule, such actions can be performed without tight timing constraints. The sooner the occurrence of this event, the faster the DSS must work, decisions be made and implemented. As a result, the DSS may become a decision-making system (DMS), or, for example, a multi-agent system with intelligent agents which are reviewed in [10]. The transition from DSS to DMS is conditioned by a human's inability to constantly increase the speed of decision-making. After all, the speed of decision-making is limited by a human's physiological abilities of environmental perception and reaction.

After an undesirable event has occurred, for its elimination or leveling its consequences it is necessary to keep a sufficiently high rate of decision-making for a certain time in the course of the case risk management (for example, fire suppression). After a short intensive hard real-time action, steps should be taken to eliminate the consequences and prevent the implementation of similar risks.

Therefore, a certain time period around an undesirable event requires a special type of system: a hard real-time risk management system. Such a system combines features of preliminary and case management that allows it both to eliminate consequences of an undesirable event and, at the same time, to prevent other undesirable events. An example of the system is given in [11], that proposes a hard real time fire suppression system. Further to this, a system was proposed to implement fire fighting with a special mechanism of targeted fire fighting (case management), and, at the same time, to organize a safe corridor for evacuation of people from the fire zone (preliminarily management).

B. Risk modeling system

The modeling system is optional within the local solution and is intended for modeling an object of risk management. In works [12] such a system is built on the basis of growing Petri nets, which allow to describe the behavior of individual elements of the system, their interactions, as well as change in the structure and / or order of the system operation in case of a certain situation (including a risk situation).

The risk modeling system can be used both to simulate application of various measures to the object of risk management (for example, at the stage of preliminarily risk management) and to predict consequences of the occurrence of risk events (at the stage of case risk management).

C. Knowledge base

The knowledge base in the local solution structurally doesn't differ much from the knowledge base in the global part of the platform. It serves for the primary acquisition of knowledge, its actualization, accumulation of new knowledge and its transfer to the global part of the platform.

D. Operational database

It contains structured data received from external sources of information, as well as data obtained in the course of operation of the local solution.

E. Gateway

The gateway is designed to receive data from the external environment (from the object where the risk management is performed). For example, if we consider production risk management, the gateway can provide access to ERP systems (1C, SAP, Oracle, Microsoft) to obtain data required for risk management in a mode that does not require real-time reaction. Besides, the gateway can provide access to industrial control systems to implement hard real-time risk management. It should be noted that in this case the data exchange may be not one-way (from the external environment to the local solution), but two-way (obtaining data about the situation from the external environment and forwarding the decisions for execution).

IV. Implementation Examples of Systems Built on the Proposed Architecture

During the period from 2008 to 2018, with the involvement of the author, a number of software systems were developed, to a degree aimed on risk management in complex organizational and technical systems. Among the customers of such systems there are large industry enterprises, such as PAO Gazprom, PJSC INTER RAOUES, T-Platforms and others.

Due to peculiar requirements of the Customers, the software products were implemented in various ways and did not fully cover the functions of risk management systems.

Table 1 reflects functions of risk management systems of the most large-scale developed systems in detail.

Despite the fact that none of the systems developed has implemented all the functions of an intelligent software platform for risk management, in general, it can be stated that the proposed architecture is operable and can be used to build intelligent risk management systems of various classes. In addition, it is obvious that the platform can be implemented using various technology stacks.

The proposed structure of an intelligent software platform for risk management, first, is notable for the ability to accumulate, generalize and disseminate best practices in risk management.

Second, it provides the ability to build hybrid intelligent models of various complexity levels by a risk management expert without the participation of programmers.

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TABLE I. FUNCTIONS OF RISK MANAGEMENT SYSTEMS

Intelligent software platform / end-point software function	**AIS AR**	**AIS Control**	**Risk management software environment**
Intelligent platform functions			
Collection of data on risk events and risk situations that have occurred in a formalized form	+ On over 400 organizations	+	+
Generalization and analysis of such data	+ With involvement of an expert	+ With involvement of an expert	-
Assessment of data validity and its transformation into knowledge	+ With involvement of an expert	-	-
Collection of data on risk management measures	+	+	+
Assessment of efficiency of such measures	+ With involvement of an expert	-	-
Generalization of knowledge of best practices	+ With involvement of an expert	-	-
Integration with external systems	± Data upload only	+ Flexible two-way integration with products on the Platform 1C: Enterprise	+ Integration with software
End-point software			
Decision support system (DSS) for preliminary risk management	+ Based on internal regulations of PAO Gazprom	+ Based on internal regulations of PJSC INTER RAOUES	+ Based on original methods of intelligent decision support
DSS for case risk management	+ Automation of standard processes defined by law	+ Automation of standard processes defined by law	-
Hard real-time risk management system	-	-	+ Allows to make decisions on managing risks of equipment failure with a responsiveness not exceeding 0.1 sec
Risk modeling system	-	-	+ For solving problems of evaluating and comparing the effectiveness of the proposed solutions
Intelligent methods and models	Fuzzy clustering[13], Fuzzy inference [14], [15] Fuzzy cognitive maps [16]	-	Fuzzy Bayesian networks [17], [18] Fuzzy cognitive maps, Fuzzy fault trees [19], [20] Fuzzy inference Fuzzy Petri Nets [21], [22]
Technology stack			
Development environment and sets of libraries	Borland Delphi	1C: Enterprise 8.2	MS VS, .Net framework
DBMS	ORACLE / FireBird	1C: Enterprise 8.2 / MSSQLServer	MySQL

Third, it is applicable for systems of different scale: corporate, regional, federal, international.

Fourth, it provides the harmonization of knowledge in the field of risk management owing both to application of a unified knowledge exchange format as a graphical risk notation (formal language), and to unified interfaces of intelligent models, supporting construction of hybrid intelligent systems of various levels of complexity.

Practical implementability of the principles and approaches to building an intelligent platform and end-point software has been proven in the course of implementing a number of projects of various levels. Practical implementation of the software is possible using various technological stacks.

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