THE KNOWLEDGE MANAGEMENT SYSTEM CONSTRUCTION FRAME OF COAL MINE SAFETY RISK BASED ON ONTOLOGY

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Abstract - In view of the existing problems of the disagree awareness, incomplete content expression and lack of standardization in identification, analysis, evaluation and description of coal mine risk source, on the basis of modern management theory, from the perspective of knowledge management, firstly we analyze the characteristics of risk source and related concepts, and then introduce the construction scheme of knowledge management system of coal mine safety risk based on domain ontology. The design and realization of the system plays an important role in promoting the knowledge potential of coal mining enterprises and improving the decision-making speed and quality of coal mining enterprises.

Keywords - Coal Mine, Safety Risk, Knowledge Management System, Ontology.

I. INTRODUCTION

As for coal mine, the primary task of safety management is safety risk management [1], which involves the five aspects of human, machine and equipment, environment, management and information, namely the unsafe human behavior, the running status of machine and equipment, unsafe environmental conditions (gas, water, fire, roof, coal dust, etc.), management defects and information stoppages. There are complex causal relationship and time-space crossing between these five kinds of risk [2]. Sometimes a small threat of them will bring out a series of other risk, which is very easy to lead to accidents.

At present, there are a variety of problems in controlling and management of coal mine safety risk [3], which mainly displays in: (1) daily monitoring information is scattered, not all-inclusive, with poor continuity and promptness, which cannot reflect the proactive monitoring; (2) it is difficult for safety manager to identity, analyze, and assess the existing hidden dangers in the all specific production process. There are some problems of disunity, incomplete content and unstandardized description; (3) without the effective knowledge management system of risk, the collecting information from risk source lacks of knowledge classification, express, search and reasoning function, which is not conducive to sharing and effective use of risk knowledge. It is difficult to ensure the continuous improvement of risk management system.

With the help of modern technology of information processing and artificial intelligence, Coal mine risk knowledge management is to combine risk source objects, operations and control measures by using the data collection, information conversion, processing and storage of knowledge and intelligent processing and management. The knowledge management of coal mine safety risk plays an important role in monitoring and controlling the hidden danger of coal mine accidents and promoting the safety management of coal mine enterprises [4]. So this paper proposed a method to build knowledge management system of coal mine safety risk on the basis of the ontology construction of coal mine safety risk, and then realize the intelligent organization, representation, storage and sharing of coal mine safety risk knowledge. It provide a basis for the risk of coal mine comprehensive application of knowledge management.

II. THE ONTOLOGY CONSTRUCTION OF COAL SAFETY RISK

Domain ontology construction of coal safety risk is one of crucial links to build coal safety risk management system [5], including the identification of coal safety risk concept, the definition of ontology concept attributes, and ontology formulation of coal safety risk knowledge and so on.

2.1. Acquisition of Coal Mine Safety Risk Information

Taking existing databases of coal mining systems (gas monitoring database, database, operation code database, library laws and regulations, etc.) as basic data source, around the subject areas of coal safety risk, we firstly extract concept from basic data source according to pre-set rules and templates. The specific steps include setting the coal mine safety risk information extraction rules and extracting templates, limiting the information entities needed to extract, using parallel programming model of MapReduce to extract the coal mine safety risk information and its classification attribute from the basic data source, taking this information as the training sample data, utilizing the ID3 decision tree classification algorithm to establish the coal mine safety risk classification model.

2.2. Concept Identification of Coal Mine Safety Risk Resource

Coal mine safety risk has more time and space and relevance, in man, machine, environment, management and other aspects has passed, the traditional single recognition method cannot identify the security risks of coal mine, therefore, we first through the accident cause analysis to study the mechanism of coal mine safety risk and cause, and combination use of Delphi method, situational analysis, empirical analysis and fault tree qualitative and quantitative analysis tools to identify risk source of coal mine safety, the formation of coal mine safety risk factors and their descriptions, and by using the ID3 decision tree classification model of coal mine safety risk classification. Finally, the safety risk of coal mine is determined as management, equipment, information, environment and personnel, etc. The core risk sources of all kinds are shown in Table 1.

After acquiring the main classes of the coal mine safety risk sources, we first use the method based on linguistic rule to analyze the grammatical and semantic features of related words in coal mine safety risk information and risk factor description, and then we utilize the method based on statistics to analyze the characters of the frequency, mutual information and information entropy of related words in coal mine safety risk information and risk factor description. According to the two characters, the entity concept and property concept in coal mine safety risk domain are judged and recognized.

2.3. Structure of the Ontology Hierarchy

The hierarchical structure is the skeleton of the ontology, so it is necessary to construct the hierarchy of ontology to establish the coal mine safety risk ontology. During the process of identifying risk concept, classifying risk source and determining the key risk source, some hierarchical relationships of risk concept are shown. At the same time, here fuzzy clustering and hierarchical clustering technology are used to find a deeper level hierarchical and containing relationships between risk concepts in coal mine safety risk knowledge management. In order to establish the comprehensive ontology hierarchy, we adopt the combination method of top-down or bottom-up to extend the secondary subclasses, finally construct the ontology hierarchy structure of coal mine safety risk.

2.4. The Definition of Attributes of Ontology Class

Attributes of ontology class mainly consist of object attribute and data attribute. Object attribute represents the relationship between classes or instances, which can be established according to the relationship between them. The data attribute represents the relationship between the class or instance and it is used to describe the details of the hidden information.

Table1: Core Risk Resources

Main safety risks of coal mine	Core risk sources
Management risks	Construction of regime
	Training of safety education
	Quality of management personnel
	Safety supervision & inspection
	Safety input
	Emergency & rescue capability
Equipment risks	Equipment mechanization
	Equipment failure rate
	Equipment inspection & maintenance
Information risks	Quality of Information source
	Effect of Information processing

	Construction of information system
Environment risks	Safety of workplace
	Dust concentration
	Gas level
	Atmospheric condition
Personnel risks	Work skills & experience
	Risk management level
	Safety attitude & responsibility
	Unsafe behavior
	Safety physiology
	Safety psychology

The class in the coal mine safety hidden danger ontology is relatively complex and involves a wide range of contents, and the object attributes in the ontology are also relatively complex with different kinds, such as isPartOf, isA, isInstanceOf, isAttributeOf, etc. Data attributes typically include generic attributes that describe classes in the ontology and specific properties that describe the instance. Through the definition of class attribute, the characteristic information of the class or instance in ontology can be represented, which makes the ontology more practical value.

2.5. The Formalization and Storage of Safety Risk Knowledge of Coal Mine

By constructing ontology, it can effectively organize the safety risk knowledge of coal mine, and can formalize and store it. On the basis of the above research content, Protégé 4.0 ontology editing software is used to create domain ontology of coal mine safety risk, including the definition of risk class and its hierarchical structure [6], the definition of the risk attributes of a class and its constraints. And then coal mine safety risk domain ontology of case database and knowledge base are set up, which consist of many instances of coal mine safety risk created according to the definition of classes [7]. At the same time, through the formalization of ontology, owl files can be used to store the safety risk ontology of coal mine, so as to provide knowledge base for establishing the knowledge management system of mine safety risk.

III. RESOLVING AND REASONING OF COAL MINE SAFETY RISK ONTOLOGY FILES

To easily disposing the program stored in the special models which read from the Ontology files and other information resources, and easily realizing the semantic reasoning based on Ontology according to reasoning rules, the coal mine safety Risk Ontology Reasoner (ROR) is proposed based on the characters of coal mine safety risk.

3.1. The System Structure of ROR

As the other ontology reasoners, the coal mine safety Risk Ontology Reasoner also has five modules, which are ontology resolver module, query resolver module, reasoning engine module, result output module and API module[8]. The system structure of coal mine safety Risk Ontology Reasoner is shown in Fig.1..

In the ROR Structure, the ontology resolver provides the function of reading and resolving the ontology stored in database or stored as other files. The ontology resolver decides the format of the ontology files supported by reasoning system, such as RDF, OWL and SWRL. The performance of resolving decides whether the reasoner can support to resolve the big ontology files.

The query resolver provides the interface for users to resolve the query commands, although SPARQL has become the standard query language of RDF, there are some other OWL candidate query languages, such as RDQL, nRQL, OWL-QL. The coal mine safety risk query resolver supports both of them.

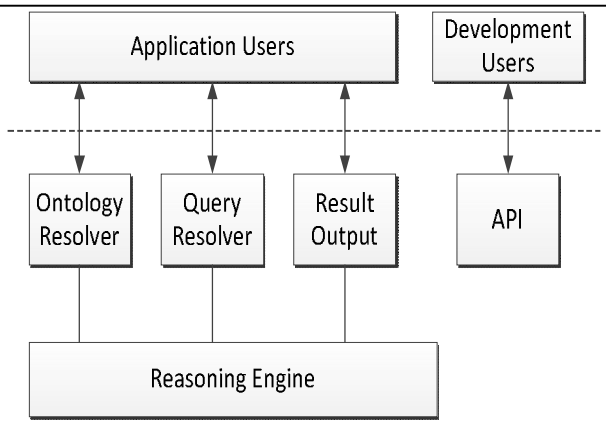


Fig.1. The System Structure of ROR

The core of the reasoner is the reasoning engine, the inner structure of the reasoning engine decides the ontology reasoning ability, and we also use the describing logic algorithm to realize the reasoning engine. The result output module packages the results inferred from the reasoning engine to suit different users. The reasoning results can display as RDF, XML and OWL.

API module faces the development users, including three parts. Which are OWL-API, DIG interface, and programming language development interface.

3.2. The Reasoning Algorithm of ROR

ROR utilizes the Rete algorithm to realize the final reasoning [9]. ROR reasoner first construct a distinguish network according to the rules, this network expresses the data dependency relationships or the rules. The Rete network is shown in Fig.2..

There are two kinds of non-root nodes in rete network, which one is 1-input node, also known as alpha node, the other one is 2-input node, also known as beta node. The 1-input nodes form the Alpha network, and the 2-input nodes form Beta network. In rete network, each non-root node has a memory area. In which, 1-input node has one alpha memory area and one input interface, but 2-input node has two memory areas and two input interfaces. The left memory area of 2-input node is beta memory area, and the right memory area of 2-input node is alpha memory area. The memory area stores the minimum unit, which is Working Memory Element, WME for short. WME includes the elements building for facts, and the element is utilized to match the pattern denoted by non-root node. Token is the list of WME, including many WMEs, and is utilized as the left input for 2-input node. Fact can utilized as the right input for 2-input node, and also can utilized as the input for 1-input node. Each non-root node represents a pattern of the left production, and the left production is represented by the path from root node to end node.

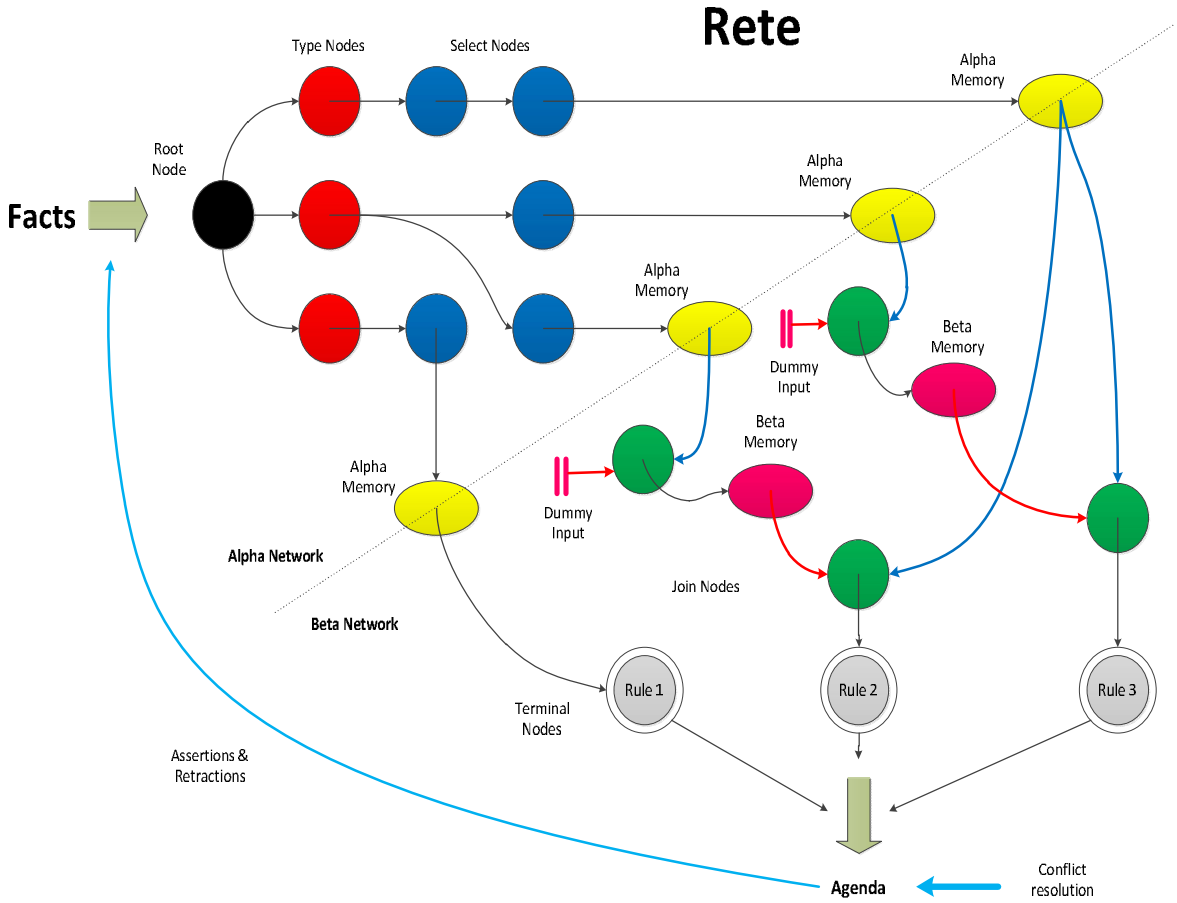


Fig.2. The Structure of the Rete Network

(1) IF the type of WME is same with the TypeNode, which is a successor node of the root node (a kind of alpha node), this fact will be saved in the alpha memory area corresponding to the TypeNode, and this WME will be transmitted to the successor node to continue the pattern matching, otherwise, the subsequent pattern matching of this WME will be abandoned.
(2) IF the WME is transmitted to the alpha node, the reasoning engine will check out whether the WME matches the pattern of this alpha node. If matching, this fact will be saved in the alpha memory area, and this WME will be transmitted to the successor node to continue the pattern matching, otherwise, the subsequent pattern matching of this WME will be abandoned.
(3) IF the WME is transmitted to the right of the beta node, the WME will be added into the right memory area of this beta node, and will match with the Token in the left memory area according the different matching action types of the beta node, such as join, projection, and selection. If matching, this WME will be added into the Token, and the Token will be transmitted to the next node, otherwise, the subsequent pattern matching of this WME will be abandoned.
(4) If the Token is transmitted to the left of the beta node, the Token will be added into the left memory area of this beta node, and will match with the WME in the right memory area according the different matching action types of the beta node, such as join, projection, and selection. If matching, this Token will be packaged into the WME and formed a new Token to continue transmitting to the next node, otherwise, the subsequent pattern matching of this Token will be abandoned.
(5) If the WME is transmitted to the left of the beta node, the WME will be packaged into a new Token, which only has one WME element as the WME list, then the reasoning engine will utilize the method of (4) to realize the pattern matching.
(6) If the Token is transmitted to the terminal node, the rules corresponding to the end node will be activated, the Activation will be built, and the Activation will be stored into the Agenda to wait for motivating.
(7) If the WME is transmitted to the terminal node, the WME will be packaged into a new Token, which only has one WME element as the WME list, then the reasoning engine will utilize the method of (6) to realize the pattern matching.

IV. COAL MINE SAFETY RISK KNOWLEDGE MANAGEMENT SYSTEM

4.1. The Framework of Ontology-Based Risk Knowledge Management System

The safety risk knowledge management system of coal mine enterprise is an information service platform facing to user demand, knowledge content and solution. With the coal mine safety risk ontology and knowledge base as the core, the system uses ontology to implement intelligent management of coal mine safety risk knowledge, and employ ontology reasoning mechanism to implement data mining and knowledge discovery [10]. In the system, semantic risk knowledge is easy to retrieve, share and transform, and relevant program of hazard screening can be generated [11]. The system can provide relevant risk information as to the continuous improvement of risk management practice accumulated valuable knowledge resources for coal mine enterprise safety risk management [12-14].The framework of safety risk knowledge management system for coal mining enterprises is shown in Fig.3..

4.2. Key Function Modules and Architecture of the System

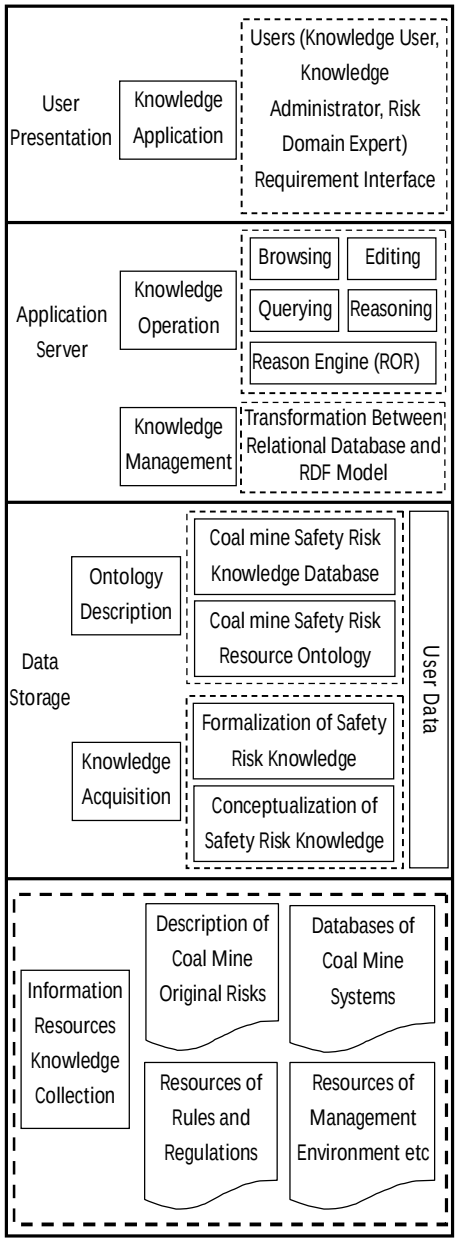


Fig.3. Framework of Safety Risk Knowledge Management System for Coal Mine Enterprises

Coal mine safety risk knowledge system has two key functions: risk knowledge management and the use of risk knowledge. The former is used to report risk, manage risk norm, and check risk knowledge during the process of constructing risk knowledge base, define the risk zone and provide the solutions and measurements of all risk points and carry on other related work [15]. Specifically, the risk knowledge base involves in management risk, equipment risk, information risk, environment risk, human behavior risk, etc. The latter aims to use risk knowledge effectively and efficiently in sharing, query and retrieval of knowledge and so on [16], so as to deepen the user's understanding of risk knowledge and guide them to take effective preventive measures in the process of actual operation. The architecture of the system divide into three layers: User presentation layer, application server layer and data store layer.

The user presentation layer provides a visual interface for users to access the resource management platform through the browser. All kinds of users (knowledge, knowledge administrator, risk domain experts) can input information or data to search for related information and knowledge according to respective needs of them through the interface. At the same time, the layer is also responsible for returning data, information and reasoning results from operational layer to users.

The application server middle layer mainly performs semantic analysis, semantic reasoning and knowledge resource management functions, which includes knowledge manipulation layer and knowledge management .Knowledge management is used to implement smooth transitions between relation database and RDF models [17]. Knowledge of the operational layer contains the semantic component analysis and reasoning machine, which implements risk knowledge reasoning by risk source Ontology Reasoner (ROR) based on ontology and knowledge base of coal mine safety risk. And the reasoning result is transferred to GUI layer [18]. What's more, the layer is also responsible for editing and modifying the ontology, which is the most critical layer in the risk knowledge management system.

Data storage layer is used to store the risk ontology, risk knowledge base (instance library), basic data of user, etc. Risk ontology is built based on a serial of text descriptions of original dangers and file resources about human-machine-environment-management-information risk, basic conceptions, relations and hierarchy structures of all kinds of laws and regulations after standardization and conceptualization, so the data storage layer also contains the basic concept, relation, hierarchy, information and RDF data, etc., is the data base of the whole system.

CONCLUSIONS

In order to improve the level of safety management of coal enterprises, aiming at many problems of coal mine safety risk management, this paper introduces an outline of build the coal mine safety risk knowledge system based on domain ontology technology from the perspective of knowledge management. The system realize the daily risk management of coal mine enterprise work under the multi-role knowledge application, and plays an important role in promoting the development of coal mine enterprise safety risk management from the extensive to fine, from traditional form to the form of network intelligence.

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