Proceedings of 2012 4th International Conference on Machine Learning and Computing
IPCSIT vol. 25 (2012) © (2012) IACSIT Press, Singapore

Formal Power Grid Knowledge Representation Based On Ontology

Yaohui WANG [1], Pengfei SUN[2], Xiaoxu SONG[1+]

[1] School of Information Engineering, Northeast Dianli University, Jilin Jilin 132012, China

[2] School of Information Engineering, Northeast Dianli University, Jilin Jilin 132012, China

Abstract. This paper mainly focuses on the research of knowledge representation in the grid domain, defines the source of knowledge in this domain and provides a classification method for the grid knowledge according to its characteristics. Varieties kinds of data from operation and management of the power system is processed as it was upgraded to a higher level form knowledge. The relation between knowledge and ontology is also illustrated in this paper. It introduces a formal representation method for knowledge in grid domain, which accurately and visually descript the knowledge in grid domain and is favorable to the extraction,sharing and reuse of knowledge. This method for processing the knowledge provides a way of solving the problem "much data lack of knowledge" and lays a foundation for the study of visualization of grid knowledge and offer supports for the safety and high efficiency of power system.

Keywords: Ontology; Knowledge; Formalization; Grid Domain

1. Introduction

Currently in power system, especially in the construction process of smart grid, an outstanding existing problem is that the power system can't efficiently process the continuously generated data and information, that the overwhelming surging data is beyond the limitation within which people and the system may fully accept, cope with and effectively use, which contributes to the failure of it being promptly organized and highly integrated. Besides, due to the fact that knowledge itself possesses abstraction, it is more often an invisible existent, which largely prevent it from being understood and its application, and finally cause a strategic decision mistake or delay.

There are more than ten general adopted ways of knowledge representation in this field, such as natural language, predicate logic, etc. Natural language, though most simple and easy to understand, has a lot of ambiguous meanings, especially Chinese. It's the first priority to avoid ambiguity when describing knowledge; predicate logic and other ways of knowledge representation also have the disadvantages such as obscurity, inefficiency in reasoning, poor visualization and difficulties in collaboration of dynamic knowledge, these problems are all especially important in power system. Researches have shown that using ontology can save these problems. The way of describing knowledge using ontology can solve these problems very well. The greatest advantage of using ontology as the way in the representation of power

[1+] Corresponding author. Xiaoxu Song, TEL:13843275692
E-mail address: song2005come@126.com

system knowledge lies in the convenience for knowledge discovery and reasoning so that it makes much easier to obtain new knowledge.

Therefore, in the present study of knowledge representation, depending on domain ontology theory, it's very necessary to adopt different varieties of means to express different types of power grid knowledge based on ontology. Meanwhile, using varieties means of describing the power grid knowledge also provide a basis for a clearer knowledge expression, extraction, sharing and the higher level of knowledge application-knowledge visualization.

2. Ontology and Knowledge Representation

2.1. 2.1. Concept and Feature of Ontology

Ontology is a philosophy term. Fundamentally, ontology is an explicit specification of conceptualization and formalization of an actual thing or fact [1]. The theory of ontology was introduced into the study of knowledge representation mainly for solving two problems: one is knowledge acquisition and realization of reuse of knowledge; the other one is interaction between people and machine, which makes it easier for computer processing knowledge and the knowledge sharing. Obviously, these two problems are connected with the essential concept of ontology, which is shown in the definition of ontology. To solve these two problems, study on knowledge representation is the premise basis.

In the field of computer research, people think the ontology is defined as follows: the ontology is the precise description form of a shared conceptualization. The features of ontology can be summarized in four aspects[2]: conceptualization, clarity, formalization and sharing.

2.2. 2.2. Relationship between Knowledge and Ontology

Knowledge is what people in long life and social practice accumulated about understanding and experience of objective reality and its regularity, is abstract product after the data and information were processed and consolidated, including acquaintances of the object's appearance, nature, relationship with others, etc.

For example, we consider "snow is white" as a kind of knowledge, which shows the relationship between snow and its color. In artificial intelligence, this knowledge is called "facts".

Knowledge is absolutely abstract while ontology is relatively specific [3]. Using concrete things to describe the abstract concept is in line with the general laws according to which people understand things and the nature of phenomenon.

2.3. 2.3. Analysis of Power Grid Knowledge

In this paper, the operation rules in power system, solutions to malfunctions and measures are defined as knowledge. Based on the above examples of knowledge and understanding of the concept of knowledge, it's appropriate to define operations rules in the power system as knowledge. Besides, the power grid knowledge also includes coping strategies for the power failure, etc. As the following two sentences illustrate some rule knowledge in the power system: If a connection line has a "T" connection, then the "T" connection line should shift load to another line. If the switch is working and the load is off, then pull the line switch.

In the actual operation of power systems, large amount of data is constantly produced. The system continuously deals with a wide range of information and provides real-time references for staff making their decisions. Varieties of data and information in the system that to be processed, however numerous, complicated or unorganized, came from a variety of power equipments, even the crucial decision-making measures are closely dependent on the equipments. Therefore, it's feasible in theory to reach the goal of understanding the whole power grid knowledge by study on the information of equipments and by acquisition of the equipment knowledge.

Based on the selected object, it’s necessary to clarify the equipment categories and their own typical characteristics and properties for the basic needs of the knowledge extraction. In this paper, considering the actual equipments being chosen, another classification method is proposed, which suggests the power equipment knowledge be divided into the following three types: naming rules, entity attributes, and real-time properties. This method was concluded after research of the text in which the common electrical equipments were described. That is shown in the table 1.

Tab 1: Equipment attributes

Naming rules	name	production date	level	texture
Entity attributes	rated voltage	rated current	Rated power	resistance

As in the table above, for different power equipment, some information can be default. In particular, some electrical equipment may have more than one name and the name here in the device naming rules is the formal name of a device or equipment. Real-time property is information generated during operation of equipments, so it is not supposed to be listed.

3. Power Grid Knowledge Representation Based on Ontology

In the grid area, source of information is various and the types of data tend to diversify. The researchers are to extract meaningful knowledge from such a large database for guiding practices, and the first question is knowledge representation.

The task power system needs to cope with in knowledge processing is enormous, attributes to a much wide range of knowledge, in addition, thousands of types of electrical equipments with different functions. In this paper, it is clearly unrealistic to cover all the knowledge and contain every detail of device information in power system, so this study focused on the well known rules of operation knowledge. Shifting to selection of electrical equipments, it concentrates on those typical electrical equipments.

The reason why ontology can represent knowledge lies in two aspects: First, the ontology itself is the standardization of understanding the nature of things [4], which helps to establish a natural link between ontology and knowledge; In addition, according to the relationship between ontology and knowledge, the use of the relevant specific ontology to describe abstract knowledge can make the knowledge easy to understand and use.

3.1. Features of Power System Knowledge

As an objective thing, electrical equipment, is very rich its forms and contents. A device may have different forms or different names, so the description of things is a very complicated process. So, in this practical study, it needs to understand the inherent characteristics of the device itself, mainly "part-whole" relationship of the equipment.

Part and object relations: An electrical equipment canbe divided into different parts, each of which differs in compositions, functions, and relationships with the whole object, but they share a same ontology type. For example, "insulation" and "the wire" share the same “wire” ontology.

Members and set relations: The set is commonly referred to no structure, especially concerning the concept of a set, "salt" and "salt pile," but in the description of the actual knowledge, taking into account the different angles and size, some collections can and should be seen as a structure, such as "a generator" and "generator".

Subclass and class relation: For some electrical equipment, you can classify it using a subclass-class relationship, in which equipments with the same properties are classified as a class, such as "step-up transformers," subordinate to "Transformers".

3.2. Power Grid Domain Knowledge Representation Based on Ontology

Based on the "part-whole" relationship with electrical equipments described above, some of the mentioned concepts in the grid domain knowledge representation ontology are described in the following text.

Class (class): class is a group of things with the same set of attributes, where the definition of class has a close description in C language. Class is represented with C_1, C2… C_n.

Instance (instance): instance is the most basic example in the class of something. It inherits characteristics of the relevant class. It's the minimum unit, and can no longer contain other things. For instance, if "I_2" is an instance of "C_1", then it is expressed as: be_instance_of(I_2 ,C_1).

Parent class and child class: for any two classes, if all instances of a class are included in another class, then these two classes have a subclass and parent relationship. If C_2 is a subclass of C, then the relationship is recorded as: be_subclass_of (C_2 ,C).

4. Grid Domain Ontology Language-GDOL

In 1991, Nehces said: "ontology defines the vocabulary of the subject areas composed of basic terms and relationships, as well as combinations of these terms and relationships used to define the terms of the extension of the rules."[5] It can be seen, the premise of the establishment of the ontology of is to understand common terms and their relationships in the research area, and gives the interpretation of terms and relationships. Therefore, in order to effectively express power network domain ontology, it's preliminary necessary to provide a complete set of rules of combining terms and relationships, and that's the definition of the grid domain ontology representation language.

4.1. Denotation Explanation in GDOL Grammar

Non-terminal: this symbol implies that the following content needs to be further explained or supplemented, using the angle brackets "< >" to explain;

Terminal: these symbols mean that there needs no more explanations.

Defining symbol: with the form ":=", it reads "defines as".

Default symbol: with the form"[]", it means the contents in the blank are dispensable.

Logic and: with the form" ǁ ", as an example, "a ǁ b" means both "a" and "b" must be correct.

Logic or: with the form "|", as an example, "a ǁ b " means either "a" or "b" is rights.

A word can be composed with letters, numbers, underscores, hyphens, and their combinations, and it's legal to use carriage return characters and various punctuation marks between words.

4.2. Content of GDOL Grammar

Content of GDOL grammar is shown below:

<ClassHeader>::=defclass<ClassName>|defPrivateClass<ClassName>

<InstanceHeader>::=definstance<InstanceName>

<ClassName>::=string

<InstanceName>::=string

<Class Representation>::=

{
{<Class Knowledge>}
}

<Class knowledge>::=<relation>|<Attributes>

<Instance Representation>::=

{

{<Instance Knowledge>}

}

<Instance Knowledge>::=<relation>|<Attributes>

<Attributes>::=< Attributes String>:[Range]<Value of attributes>

<Attributes String>::=<Device attributes>|Definition| Grammar |cardinality

<Device attributes>:: =Name|| Production date|| Texture|| Level| rated voltage | rated current| rated power| resistance

<Value of attributes>::=string

<relation>::=be_subclass of|subclass|instance|be_instance_of

5. Example of the Application

The codes below give the way how an instance is defined, choosing step-up transformer as an example. As is shown in the description, kinds of attributes are assembled to describe the ontology.

```
definstance step-up Transformer
{
be_instance_of: transformer
   Attributes: name: step-up Transformer
               produce date :17th,Mar,1991
               material: steel
               level: 20kv
               shape: square
               size: SFSZ10-K-180000/220
}
```

From the example above, it is clear that GDOL language is a kind of formal language between natural language and logic language with a flexible forms and articulate structure. The ontology and knowledge representations are combines together in order to meet needs of knowledge representation of electrical equipments.

6. Prospect

At present, research and application of ontology in the power grid field is still in its infancy, especially the rules in ontology construction are not unified. In this paper, some knowledge in power grid domain was represented with the concept and relationship between concepts and instances based on the integrated use of ontology theory, especially for different types of knowledge provided two different methods. They are both formal and structured ways in description of knowledge and are also easy-understanding natural ways people hope to see. Ontology provides a clear iconic way for knowledge representation, which can improve interoperability, facilitate knowledge sharing and provides a necessary support for a higher level of power grid knowledge representation-the power grid knowledge visualization display.

7. References

[1] Guarino. Formal Ontology and Information Systems [C]. proceedings of FOIS'98. Trento, Italy, 1998

[2] Lu Ru-qian；Jin Zhi；Chen Gang. Ontology-oriented requirements analysis [J]. Application research of computers. 2000,11(8):1009-1017

[3] Deng Zhi-hong；Tang Shi-wei, et al. Overview of Ontology [J]. Journal of Peking University. 2002,38(5):731-733

[4] Hu Min. Research on domain ontology-based knowledge acquisition and reuse [D]. Beijing：Beijing University of Chemical Technology. 2006.5

[5] Yu Jie；Wang Lei；Xia An-bang. Construction and research of power grid operation repository based on ontology [J]. Application Research of Computers, 2008, 25(12): 3515-3516