Ontology-based Research on Wind Power Plant Information Interaction

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Abstract

At present, wind power industry has developed rapidly in our country, and has also promoted the step of wind power plant information construction. But in this process, it's impossible to set up a uniform wind power plant management information system using conventional technology and method, because the wind power plant's devices span a long time, have many categories and the information model and communication protocol are also diverse in different wind turbines. Thus, this paper imports knowledge-sharing-based ontology semantic technology, builds the ontology on the basis of wind power plant information model and describes it using OWL. It achieves the wind power plant information sharing, interaction and procession at the semantic level, and provides a new method to build a uniform wind power plant management information system.

1. Introduction

At present, as an important composition of our country's energy configuration adjustment, wind power electricity generation has got rapid development. At the same time, it has given an impetus to the information construction of the wind power plant. It's very important to build the uniform management information system in the process of wind power plant informationization and internetization construction. But there are some differences from other industry information construction, and there exist some obvious issues mainly in the great difference between wind power plant equipment, such as the big time span of equipment purchase, the great difference in equipment type. In order to save money, it's common for wind power plant to run electrical machines bought in several periods. Also, the wind turbines worked in wind power plants are made by different factories, it makes difficult using conventional technology and method to realize the uniform information management. Based on the problems mentioned above, this paper introduces the knowledge-sharing-based ontology semantic technology, lucubrates the mapping from different physical equipment to logical equipment, covers properties of wind power plants' relative conceptions and their relations, and describes the wind power plant information model using the web ontology language – OWL. It implements the information sharing, interaction and dealing in semantic level, and provides a new way to the further construction of knowledge-sharing-based uniform wind power plant management information system.

e-Forensics 2008, January 21-23, 2008, Adelaide, Australia.

2. Ontology and web ontology language

2.1. Ontology

The conception of ontology derives from philosophy and has been given new definition with the development of artificial intelligence. The original conception is not complete, so the definitions vary with time, among which the one proposed by Studer in 1998 is more precise and comprehensive: Ontology is an explicit formal specification of shared conceptualization [3].

From the definition of ontology, ontology is a semantic base for different objects (people, machines, software systems and so on) in the domain (specific or wide range) to communicate (converse, interoperate, share and so on), that is ontology provides an explicit definition of common view. The common view mainly works for machine, but machine is unable to understand the semantic expressed in natural language like human. Presently, computer can only regard text as character string to process. Ontology discussed in computer science mainly relates to how to use ontology to express common view, that is the formal issue of conception, which contains description languages, building method of ontology and so on.

2.2. Web ontology language

Web Ontology Language (OWL) is suitable for applications that not only need to provide readable document content with users but also demand content information dealing [4]. The expression of entities and their relations is called ontology. Compared with XML, RDF and RDF Schema, OWL has more mechanisms for semantic expression, so it exceeds the ability of expressing machine-readable document content in internet. OWL has been developed on the base of XML, RDF and RDF Schema, and has passed through many description languages, the relationship between them is illustrated in Fig. 1.

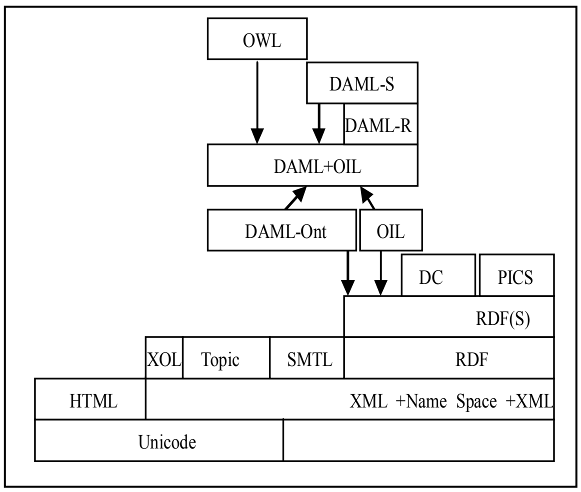

Figure 1. **Ontology language stack**

XML provides surface syntax for structured documents, but doesn't give any semantic restriction to documents' meaning. XML Schema is a language which constrains XML document structure and extends data type for XML. RDF is a data model of objects (or resources) and their relations, and provides simple semantic, so the data model can be expressed by XML syntax. RDF Schema is a glossary of properties and classes describing RDF resources and offers semantic of hiberarchy about properties and classes. The reason why OWL is chosen as ontology description language is that OWL adds more glossaries to depict properties and classes, such as disjointness between classes, cardinality (e.g. just one), equivalence feature, various types of property, property characteristics (e.g. symmetry) and enumerated classes.

3. Wind power plant information model and its ontological description

3.1. Wind power plant information model

In the wind power plant information model illustrated in Fig. 2, the highest level is called Logical Device (LD), which is decomposed into Logical Nodes (LN)[1]. A logical node consists of a collection of related data, called data classes (DC). Each data class inherits a collection of properties, as defined by a so-called Common Data Class (CDC) to which it is assigned. A common data class consists of a collection of attribute records. The most basic detail of data can be found in the type-attribute of a common data class. A server hosts at least one logical device. This standard could for example be used to assign a logical device to a specific wind turbine of a wind power plant. Thus an LD contains a collection of specific logical nodes belonging to this wind turbine. The logical node is destined to provide information about wind turbines of different type, information about logical devices and nameplate and health of logical node physical device.

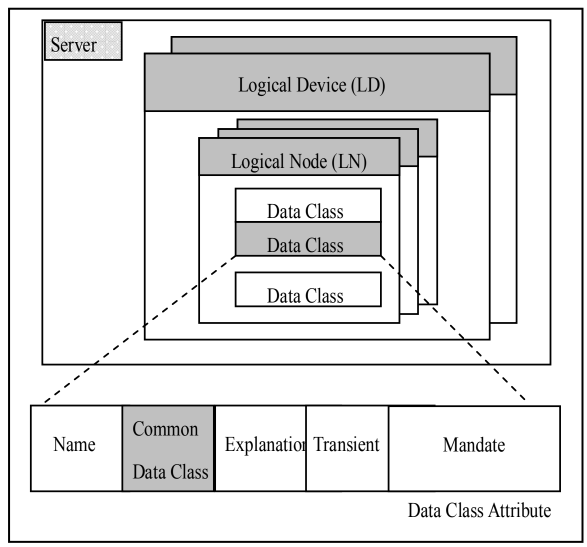

Figure 2. **Wind power plant information model**

In each logical node, information and data are divided into different classes called data classes, such as the state information data class, alarm information data class, peer information data class, common information data class and so on. Each data class contains data class name, common data class, explanation, transient and mandate. Some of these classes shall be mandatory (indicated with an "M" in tables) and others optional (indicated with an "O" in tables). The specific LN's classes are originated by a physical turbine break down into functional parts (e.g. rotor, transmission, generator, yawing, etc), but collections of common information can also be represented in a specific LN (e.g. alarm log, event log, etc). The names of wind power plant specific logical nodes shall be unique and always begin with 'W', followed by three capitals representing the content.

3.2. Wind power plant information model Ontology and its semantic description

In the wind power plant information model built above, it refers to relative conceptions of wind power plant equipment, among which the important ones are logical device, logical node and data class, and they are inheritable. If the relation is described by the common used XML Schema [2], it can only defined in syntax and structure, thus it's very formal and lacks flexibility and expansibility. This paper builds ontology for the information model and uses web ontology language-OWL to depict it so as to realize the expression of conception's properties and relation in semantic level. The ontology built is as follows:

```
<?xml version="1.0"?>
<rdf:RDF
    xmlns:rdf=http://www.w3.org/1999/02/22-rdf-syntax-ns#
    xmlns:xsd="http://www.w3.org/2001/XMLSchema#"
    xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#"
    xmlns:owl="http://www.w3.org/2002/07/owl#"
    xmlns="http://www.owl-ontologies.com/unnamed.owl#"
    xml:base="http://www.owl-ontologies.com/unnamed.owl">
  <owl:Ontology rdf:about=""/>
  <!--definition of wind power plant service -->
  <owl:Class rdf:about="#tServer">
   <rdfs:label xml:lang="en">Server</rdfs:label>
   <rdfs:subClassOf rdf:resource="#WindPlant"/>
  </owl:Class>
 <!—definition of “is part of ” property-->
  <owl:ObjectProperty rdf:about="#is_part_of">
  <rdf:type
rdf:resource="http://www.w3.org/2002/07/owl#TransitiveProperty"/>
  </owl:ObjectProperty>
 <!—description of logical device-->
  <owl:Class rdf:about="#tLD">
   <rdfs:label xml:lang="en">LD</rdfs:label>
   <rdfs:subClassOf>
    <owl:Restriction>
     <owl:onProperty rdf:resource="#is_part_of"/>
     <owl:allValuesFrom>
      <owl:Class rdf:ID="tServer"/>
     </owl:allValuesFrom>
    </owl:Restriction>
   </rdfs:subClassOf>
   <rdfs:subClassOf rdf:resource="#WindPlant"/>
  </owl:Class>
 <!—description of logical node-->
  <owl:Class rdf:ID="tLN">
   <rdfs:label xml:lang="en">LN</rdfs:label>
   <rdfs:subClassOf>
    <owl:Restriction>
     <owl:allValuesFrom>
      <owl:Class rdf:ID="tLD"/>
     </owl:allValuesFrom>
     <owl:onProperty>
      <owl:ObjectProperty rdf:ID="is_part_of"/>
     </owl:onProperty>
    </owl:Restriction>
   </rdfs:subClassOf>
   <rdfs:subClassOf rdf:resource="#WindPlant"/>
  </owl:Class>
 <!—description of data class-->
  <owl:Class rdf:ID="tDC">
   <rdfs:label xml:lang="en">DC</rdfs:label>
   <rdfs:subClassOf>
    <owl:Restriction>
     <owl:allValuesFrom>
      <owl:Class rdf:ID="tLN"/>
     </owl:allValuesFrom>
     <owl:onProperty>
      <owl:ObjectProperty rdf:ID="is_part_of"/>
     </owl:onProperty>
    </owl:Restriction>
   </rdfs:subClassOf>
   <rdfs:subClassOf rdf:resource="#WindPlant"/>
  </owl:Class>
</rdf:RDF>
```

In the information ontology built for the wind power plant, relations between concepts are depicted by OWL. The inheritable relationship of conceptions is depicted through the defining of “is part of” property and so it restricts the definition domain of conceptions. The logical relation between conceptions is expressed by definition of transferability of “is part of ” property. The “is part of” property is defined separately so as to give flexible modification to properties and redefine semantics without doing much modification of coding. Ontology is accurate and abundant to express conceptions and their relation, obviously it has advantages in semantic and conception-sharing.

4. Conclusions

This paper discusses about the difficulties and problems which occurr in the wind power plant informationization process, puts forward a solution based on ontology technology, introduces conceptions of ontology and its description language – OWL, then builds wind power plant information ontology on the basis of the information model and implements the ontology's semantic description. To a certain extent, it indicates ontology's advantage in semantic expression and knowledge sharing and provides new method for the unification of wind power plant information management.

5. References

[1] IEC 61400-25, "WIND TURBINES Part 25-1: Communications for monitoring and control of wind power plants–Overall description of principles and models", 2004.

[2] IEC 61400-25, "WIND TURBINES Part 25-4: Communications for monitoring and control of wind power plants–Mapping to XML based communication profile", 2004.

[3] Studer, Benjamins and Fensel, "Knowledge Engineering: Principles and Methods", Data and Knowledge Engineering. vol.25, 1998, pp.161-197.

[4] W3C, "OWL Web Ontology Language Guide", http://www.w3.org/TR/2004/REC-owl-guide-20040210/, 2004.