

# Research on the Construction Method of Emergency Plan Ontology Based-on OWL

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**Abstract**—How to solve the emergency properly has been an important aspect to test the administrative ability of governments. Emergency plans describe the domain knowledge of emergency handling, which is the basis of high-efficient response, and it's necessary to share knowledge in emergency plans among participating organizations. Presently, knowledge representation and sharing is becoming the mainstream, so how to construct the emergency plan ontology is the key for high-efficient response. A new construction method of owl ontology oriented to emergency plan is proposed, in order to solve the problems above. We analyzed the requirement of Emergency Response Systems for emergency plan knowledge, regarded emergency plan's application as guidance and pay attention to experts' participation and collaboration in ontology construction. It is shown in practice that the new method is able to guarantee the quality of the emergency plan ontology and provides formal knowledge representation to support knowledge sharing and collaborative work among different organizations in Emergency Response Systems.

**Index Terms**—Emergency plan; ontology construction; emergency response; OWL

## I. INTRODUCTION

Emergency service and emergency event handling is a modernization symbol of a city. With the acceleration of economics developing and constant expansion of city area in China, cities in China must respond to various emergencies in time and effectively to meet urban residents demand for public security. As the most important components of E-Government, in recent years, Chinese government has begun to build Emergency Response Systems (just like 911 Dispatch Center in US, and 112 Dispatch Center in Europe) in lots of cities to deal with various possible emergencies<sup>[1]</sup>.

As the development of E-Government, we can see that, data integration, resources sharing and collaborative work are choke points which restrict the sustainable development of Emergency Response Systems in E-Government, also they are the most important aspects of the construction of present Emergency Response Systems. Emergency Response Systems offer emergency decision makers knowledge to command and dispatch, and most of the knowledge exists in various emergency plans. However, at present, emergency plans are in wide varieties, established by different departments from different aspects, and almost stored in static text, which results in difficulty in knowledge sharing and collaborative work.

In order to meet the situation of present Emergency Response Systems, we put forward an owl emergency

plan ontology construction method to build an emergency plan ontology, which can provide knowledge representation mechanism generally acknowledged in emergency plan field and is basis for knowledge sharing and collaborative work in different organizations in certain Emergency Response Systems. As most ontology construction is oriented toward specific field, if there isn't a good guiding method, it's difficult to keep consistent during various domain ontology and also blocks the scale and standard construction of ontology. So study on construction method plays an important role in ontology's application.

## II. RELATED RESEARCHES

The procedures of ontology construction are different from each other, by considering differences in specific field and concrete engineering, and there is no standard ontology construction method. It is generally believed that the 5 criteria for ontology design, provided by Gruber in 1995 is very influential<sup>[2]</sup>:

### A. Clarity:

An ontology should effectively communicate the intended meaning of defined terms and definitions should be objective.

### B. Coherence:

An ontology should be coherent: that is, it should sanction inferences that are consistent with the definitions.

### C. Extendibility:

An ontology should be designed to anticipate the uses of the shared vocabulary. It should offer a conceptual foundation for a range of anticipated tasks, and the representation should be crafted so that one can extend and specialize the ontology monotonically.

### D. Minimal encoding bias:

The conceptualization should be specified at the knowledge level without depending on a particular symbol-level encoding.

### E. Minimal ontological commitment:

An ontology should require the minimal ontological commitment sufficient to support the intended knowledge sharing activities.

The main existed approaches to construct ontology include TOVE method, Skeletal method, KACTUS method, SENSUS method, IDEF5 method and General method etc. These methods were summarized through reverse engineering in independent cases in the

background of diverse domain<sup>[3]</sup> and each of them has special emphasis.

General method<sup>[4]</sup> developed by Stanford University School of Medicine, mainly used for construction of domain ontology. Its seven steps are: a. Determine the domain and scope of the ontology; b. Consider reusing existed ontologies; c. Enumerate important terms in the ontology; d. Define classes and the class hierarchy; e. Define properties of classes—slots; f. Define the facets of the slots; g. Create instances. IDEF5 method<sup>[5]</sup> provides a structured approach, which could help domain experts develop and maintain domain ontology effectively. The IDEF5 ontology development process consists of the following five activities: organizing and scoping、data collection data analysis、initial ontology development、ontology refinement and validation. TOVE method<sup>[6]</sup> is specialized in developing TOVE ontology with first-order predicate logic. Skeletal method<sup>[7]</sup>, also called enterprise method is specialized in developing enterprise ontology, however, it just supplies guiding principle for ontology development. KACTUS engineering method<sup>[8]</sup> is used to solve knowledge reusing problems during circle life in technical system and KACTUS refers to “modeling knowledge about complex technical systems for multiple uses”. SENSUS method<sup>[9]</sup> develops method and technology route for SENSUS language ontology applied to natural language processing.

Summarized by these ontology construction methods, we find that some methods primarily provide the overall guidelines of the ontology development and less description in detail; others describe the construction steps in detail, however, the most description are about how to express the information formally, as to the problems we have to face in practical development process, such as the knowledge collecting in early times, analysis and the cooperation between developer and domain expert, are not described particularly. Therefore, these construction methods are not fully suitable for emergency plan domain. It's necessary to put forward an ontology construction method oriented to emergency plan domain and guarantee this method play a better role in emergency area.

### III. THE CONSTRUCTION METHOD OF EMERGENCY PLAN ONTOLOGY BASED-ON OWL

Emergency plan<sup>[10]</sup> is scientific and effective plans and arrangements established in advance for emergency, belonging to national policy documents. It has its own features of the domain. First, emergency plan has wide varieties, established in different departments from different aspects and there is no existing resource for reference to build emergency plan ontology, such as thesaurus, terminology classification table, reusable ontology etc. Second, we must consider the application of the emergency plan ontology, while building it. According to the several ontology construction methods above and emergency plan field features, meanwhile, paying attention to experts' important role in ontology construction, this paper proposed an owl ontology construction method oriented to emergency plan field. Ontology construction method is shown in Figure 1:

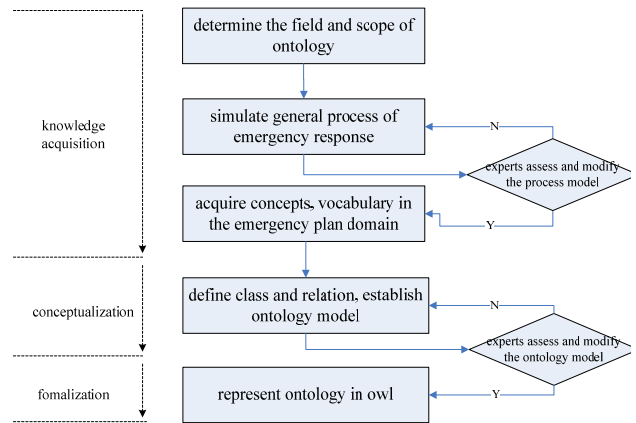


Figure 1. Ontology construction method

In this paper, the ontology construction method can be divided into 3 separate levels: (1) Acquisition of real domain knowledge; (2) Knowledge conceptualization, extracting concepts from real knowledge system; (3) Knowledge formalization, converting the domain knowledge into processable form for computer instruction. Each level has independent and explicit goal, while paying attention to domain experts' important role in ontology design, which is generally accepted in the process of domain ontology construction. In the phase of domain knowledge acquisition, we consider simulating general process of emergency response for emergency, analyzing emergency plan knowledge involved in every link in the response process. Then, concepts and words contained in emergency plan knowledge will be discussed. It can void the blindness of emergency plan field knowledge analysis during the ontology construction guided by ontology application. As a result, we may achieve the core concepts in emergency plan field quickly and efficiently. The following is the detailed content of emergency plan ontology design method.

#### A. Determine the domain and scope of the ontology

Determining the domain and scope of the ontology could be use as the starting point of domain ontology developing and we should be clear about ontology domain、ontology application purpose、type of questions could be answered by ontology、manager and application objects of ontology. These questions could be adjusted at any moment, but it is better to be relatively stable, because of the scope of model defined by them. Although domain ontology should cover all knowledge in domain, enlarging the scope of ontology immoderately will increase complexity and cost of the project, even lead to failure. So, we'd better control the ontology scope and satisfy requirement in smaller scope according to actual demand and knowledge domain experts provided.

Seeing from its appearance, the construction of domain ontology serves for computers. In fact, it offers information service to users. In the paper, emergency plan ontology aimed at implementing formal representation of emergency plan knowledge and being basis for knowledge sharing and collaborative work in different organizations in Emergency Response Systems.

### B. Simulate general process of emergency response

By analyzing types of typical emergency disposal cases, studying emergency management, and combining with related workflow knowledge, we achieve general process of emergency response for emergency, shown in Figure 2:

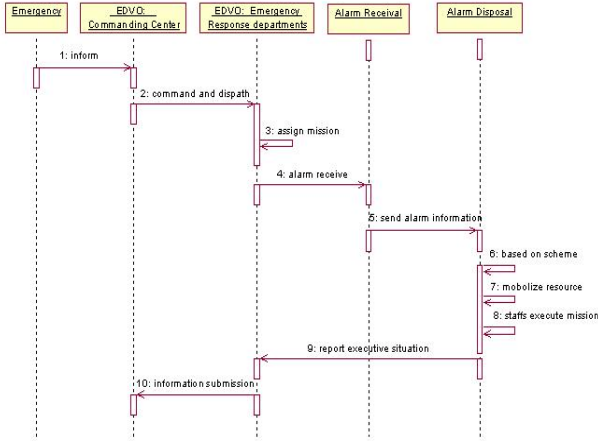


Figure 2. General process of emergency response

According to the general process of emergency response, we find commanding center understand emergency and carry on commanding and disposing; departments of different levels assign missions; emergency staff receive and dispose alarm that compose the process. After analyzing the process, we achieve the emergency plan knowledge required in emergency response, then emergency plan ontology scope can be further determined, which decrease complexity and show clear direction for domain concepts extraction in the following. Additionally, the process also needs to be assessed and modified by domain experts until it is acknowledged by most people.

### C. Acquire the core vocabulary and concepts in the domain

In the emergency plan knowledge scope defined by the process model, we extract core vocabulary and concepts and enumerate important terms. In general case, the choice and acquisition of concepts are usually based on thesaurus or the comprehensive dictionary so as to guarantee the integrity of the concepts system. Even though labor force and time are limited and the study of emergency plan ontology mainly emphasizes on its application in Emergency Response Systems in the paper, the emergency plan in our study still refers to more than 300 national and provincial emergency plan. Then, we extract concepts within emergency plan knowledge required by emergency response.

### D. Define classes, properties and their relations, establish ontology model

In the phase, the ontology model is established by analyzing and abstracting emergency plan knowledge collected. First, we should define classes, properties and their relations, because classes are the core of ontology used to describe domain concepts and the implied knowledge will be achieved based on explicitly defining

classes and relations, and through specific reasoning mechanism. We define with the following rules:

(1) The definition of ontology class should be definite and highlights key properties. A concept may have synonyms, but one concept can only have a class. A new class usually adds new properties its parent class doesn't possess or overlays its parent class's property binding.

(2) Property of class is the most important characteristic to distinguish class. The following four object characters can be used as ontology property: intrinsic characters; extrinsic characters; parts, if the object is structured; these can be both physical and abstract "parts"; relationships to other individuals, these are the relationships between individual members of the class and other items. At the same time, defining the bound of property refers to the character of property value.

(3) The logical relations between classes can be defined by means of top-down development process: we start with the definition of the most general concepts in the domain, and then specialize the class by creating some of its subclasses.

(4) Add individuals on the basis of bound of class and property. Domain experts pay attention to the precision of class and its relation. Extract classes from the nomenclature in upper step and the remainders are used as property or individual. Some classes and relations can be directly achieved from the existed knowledge in upper step. The others need to be found out from the information. In normal case, the ontology developers concern about the detailed knowledge representation rather than the detailed content of the domain knowledge, because it is good for computer encoding with the help of copying inner classes and relations in sufficient size<sup>[11]</sup>.

The ontology model confirms to the domain knowledge system, and reflects the knowledge which is commonly accepted in the domain<sup>[11]</sup>. In the process of modeling, the domain experts are needed to evaluate and modify the ontology model, if class lacking、conflict、logical relation imprecision and some other problems occurred, it needs to rollback and be reanalyzed to obtain knowledge.

### E. Represent ontology in OWL

After building the ontology model, we need to represent the ontology model in OWL. OWL<sup>[12]</sup> offers rich axioms which not only describes the class、property、individuals of knowledge accurately, but also describes the relations among them precisely, and makes good preparations for knowledge reasoning. OWL uses the following methods to describe objects: concepts expressed by classes, using "rdfs:subClassOf, rdfs:subPropertyOf" to classify concepts and relations; using "sameClassAs, samePropertyAs, inverseOf, equivalent To" to represent synonymous and antonymous relations; logical combination relationships are implemented by means of "intersectionOf, unionOf, complementOf, one of". The bound relation is expressed by "domain, range, hasValue, allValueFrom, someValueFrom, minCardinality". The

axiom definition uses the form of “disjoinWith, uniqueProperty, unambiguousProperty, transitiveProperty”.

#### IV. CONSTRUCTING AN OWL EMERGENCY PLAN ONTOLOGY

Seeing from Figure 2., we find commanding center understand emergency and carry on commanding and disposing; departments of different levels assign missions; emergency staff receive and dispose alarm that compose the process. There are two basic research objects: emergency plan and emergency in the process. Emergency plan knowledge mainly contains commanding center、emergency response departments、executing staffs、mission、scheme、resource etc. Based on concepts acquisition principle, the emergency plan ontology is divided into two basic classes: emergency class and emergency plan class.

The first layer concept: The emergency plan ontology studied has two basic classes: emergency class and emergency plan class. Emergency plan class owns an object property: “solve”, whose range is “emergency class”, while emergency class has another property: “solved”, whose range is “emergency plan class”. Apparently, the two object properties are inverse relationship (owl:inverseOf).

The second layer concept : Emergency plan class contains 4 subclasses: Subject、Mission、Scheme、Resource. Subject class has an object property: “carry out”, range: “Mission class” ; Mission class has an object property: “has method”, range: “Scheme class” ; Scheme class has an object property: “need”, range: “resource class”.

The third layer concept : Subject class can be further divided into 3 subclasses: Commanding Center , Emergency Response Departments , Execution Staffs. The 3 subclasses are mainly in “assort with” relation.

Finally, we use firefight emergency plan as example and add individual for each class, which describe relations among the fire fighting commanding center, the fire fighting lochus,the detachment and the fire fighters visually and intuitionistically, meanwhile clearly shows the detailed mission, the referring scheme, and available resources for fire fighters.

The following Figure 3 shows the logical relation in emergency plan ontology.

We use protégé developed by Stanford University as ontology editing tools. The interface style of protégé is consistent with windows application style, and ontology structure is shown in tree hierarchy structure. So it is easy to use. Base on the logical relation shown in figure2., we complete the emergency plan ontology model in Figure 4. by clicking relevant items to produce or edit class、subclass、property、individuals and so on.

Currently, protégé supports XML, RDF, OWL and other ontology languages [13], and this paper describes emergency plan ontology formally in owl, parts of the code are as follows:

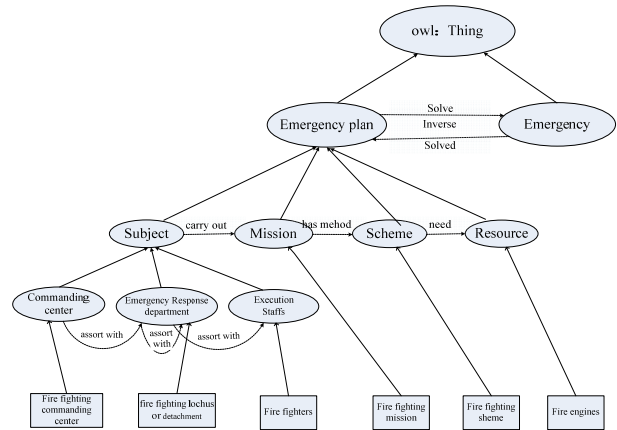


Figure 3. Logical relation in owl emergency plan ontology

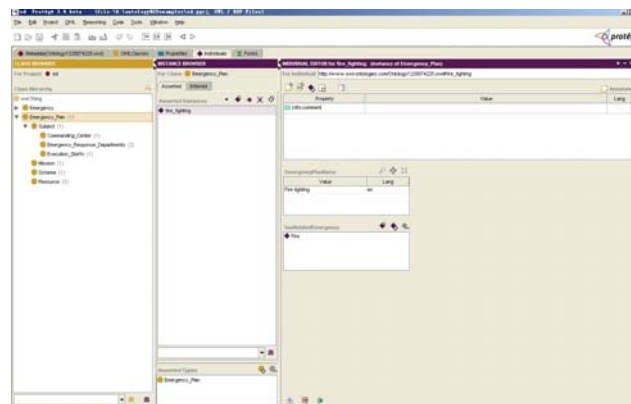


Figure4. Emergency plan ontology in protégé

The definition of emergency plan class:

```
<owl:Class rdf:ID="Emergency_Plan">
  <rdfs:subClassOf rdf:resource="http://www.w3.org/2002/07/owl#Thing"/>
```

```
</rdfs:subClassOf>
```

The adding of emergency plan property:

```
<owl:ObjectProperty rdf:ID="solve">
  <rdfs:domain rdf:resource="#Emergency_Plan"/>
  <rdfs:range rdf:resource="#Emergency"/>
  <owl:inverseOf>
    <owl:ObjectProperty rdf:ID="solved"/>
  </owl:inverseOf>
</owl:ObjectProperty>
```

The adding of subclass:

```
<owl:Class rdf:about="#Subject">
  <rdfs:subClassOf rdf:resource="Emergency_Plan"/>
</owl:Class>
```

.....

We assumed that our ontology construction method can void the blindness of emergency plan field knowledge analysis and also decrease the complexity of the project

with the help of the general process of emergency response identifying ontology knowledge scope. In addition, the emergency ontology construction method based-on OWL in our study is divided into 3 separate levels. The hierarchical idea makes every step with independent and clear objective, at the same time, directs us to perfect ontology in application and improve ontology construction method in the future.

## V. CONCLUSIONS

Formal representation of emergency plan knowledge is the premise of knowledge sharing and collaborative work in different organizations in Emergency Response Systems, which obtains more and more people's attention in emergency management field. The study of ontology construction can not merely remain in the exploration of theory .We should understand its complexity in practice. In this paper, an ontology construction method oriented to emergency plan domain is proposed, and the emergency plan ontology is constructed under the background of emergency plan's practical application during emergency response with explicit target. In practice, the method works well and can guarantee the quality of emergency plan ontology.

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