

Operational Plan Ontology Model for Interconnection and Interoperability

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Abstract. Aiming at the assistant decision-making system's bottleneck of processing the operational plan data and information, this paper starts from the analysis of the problem of traditional expression and the technical advantage of ontology, and then it defines the elements of the operational plan ontology model and determines the basis of construction. Later, it builds up a semi-knowledge-level operational plan ontology model. Finally, it probes into the operational plan expression based on the operational plan ontology model and the usage of the application software. Thus, this paper has the theoretical significance and application value in the improvement of interconnection and interoperability of the operational plan among assistant decision-making systems.

1. Introduction

The theory research and equipment construction of the system operations based on the information system are developing rapidly. The assistant decision-making system's demand for the data and Knowledge processing of the operational plan is on the increase. The traditional expression method of the operational plan cannot adapt to the sharing and interaction among systems, which has severely impeded the system combat capability [1]. Ontology theory, extensively studied by civil information systems, has been proved effective in solving similar problems [2], so it has a great potential in the application to military information systems [3]. Therefore, revolving around the bottleneck of the system combat capability, this paper will make a deep research on the operational plan ontology model with the intention of promoting the settlement of the problems of interconnection and interoperability of the assistant decision-making system.

2. Analysis of the method of operational plan expression

2.1. Traditional expression method and its problems

Among the same type of assistant decision-making systems, operational modes of specific domains correspond to several fixed description templates which are used for the expression of different types of operational plan, while the fixed description templates for the different type of assistant decision-making systems vary [4-5]. In order to deal with the problems of interconnection and interoperability, some standards or data models with the description format of distributed static data structure appear to support the fixed description templates to express [6].

The following problems exist in the above expression method: First, fixed description templates cannot cope with the flexible descriptions of operational plan in practical operations. Second,



standards or data models have difficulties in realizing the interconnection and interoperability of the different type of heterogeneous assistant decision-making systems. Third, adapters are necessary when format conversion of the heterogeneous operational plan between two different types is under conduction. The installation of adapters will immensely add to the workload and decrease the reliability.

2.2. Prominent advantages of the ontology model

Operational plan ontology model, equivalent to the meta-model of the expression of operational plan, plays a dual role: First, it provides a unified framework of the operational plan model, which guides the development of operational plan models in various professional domains of the different type of assistant decision-making systems. Second, it regulates expression of the elements and relationships of the operational plan, so as to guarantee the consistency of the general description of operational plan among the different type of assistant decision-making systems.

Ontology model can effectively cope with the problems of operational plan expression. First, the development of multiple types of operational plan models of diverse scales will meet the need of flexible description. Second, operational plan elements are unified and the reliance on fixed templates is eliminated, which ensure the interconnection and interoperability. Third, in the process of format conversion of the operational plan, the complexity and workload of are reduced, and the reliability increases in both newly developed and existing systems.

3. Elements of operational plan ontology model

Operational plan ontology model consists of the following five elements in the operational plan domain knowledge: category, category attribute, relationship, axiom and instance, which can be defined as:

$$\text{Onto_plan}=\langle C, A, R, X, I \rangle$$

Wherein: C, expressing the category, is the set of objects with similar features, and it describes the important concepts of operational plan domain knowledge. A, expressing the category attribute, is a set of properties of the category, and it describes the inner structure of the operational plan ontology model category. R, expressing the relationship, is the interrelation between categories (category and attribute), and it describes the interaction between the categories (categories and attributes) of operational plan ontology model. X, expressing the axiom, is the statement of permanent validity, and it describes the valid assertion in any case in the operational plan domain knowledge. I, expressing the instance, is the concrete object corresponding to the category, and it describes the specific element of operational plan domain knowledge.

4. The basis of construction of the operational plan ontology model

4.1. Fundamental basis of the data hierarchy

Two aspects are included in the basis of the construction of the data hierarchy. First, the content of the operational plan that needs to be exchanged among assistant decision-making systems. Second, user's demand for data description and expression while processing the operational plan. Thus the following three elements are determined. (1) Category. All the categories necessary for the description are included. (2) Category attribute. The demand of data exchange is met. (3) Instance. All the elements necessary for description are included.

4.2. Advanced basis of the knowledge hierarchy

Three aspects are included in the basis of the construction of the knowledge hierarchy. First, the huge amounts of relationships among the internal elements of the operational plan. Second, the logical test of the operational plan. Third, the intelligent reasoning of the operational plan [7]. The following two elements are determined in this way. (1) Relationship. All the relationships among the various factors

are included. (2) Axiom. The inspection and judgment rules and professional operation rule are included.

5. Construction of operational plan ontology model

According to the basis of construction, the operational plan ontology model for interconnection and interoperability, including category, attribute and relationship, is at a semi-knowledge level, and the other two elements, including axiom and instance, can be expanded according to the application demand.

5.1. Category

The operational plan ontology model is composed of 14 categories (1+7+6), as is shown in figure 1. There are one general category and seven core categories, in which time category and space category are generic categories, basing on relative references [8-9]. There are six subordinate categories. The solid lines between the core and subordinate categories in figure 1 symbolize their affiliated associations. The definition of category is shown in table 1[10].

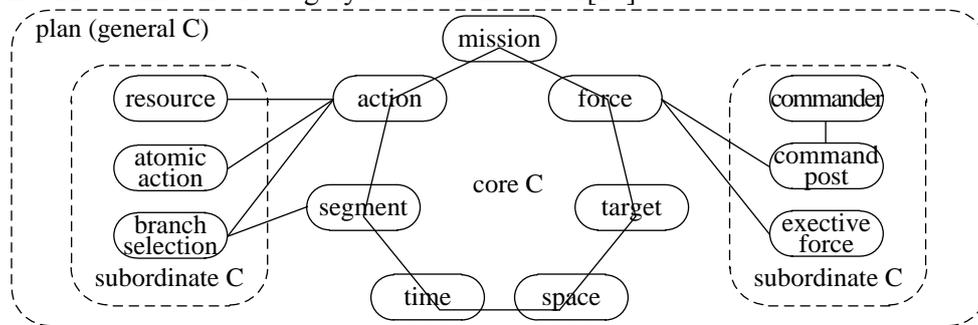


Figure 1. Composition of categories of operational plan ontology model

Table 1. Definition of categories of operational plan ontology model

No.	C name	C definition
1	plan	the plan of readiness and implementation for the implementing mission
2	mission	the task of the force for achieving the predetermined objective
3	segment	the general designation of the schedule and phase, consisting of a series of complicated processes and actions
4	action	attacks or defenses carried out by forces in order to accomplish the mission
5	force	the general designation of various organizations, staff and armory for the implementing mission
6	target	the object of attack, capture, or defense in actions
7	atomic action	the tactical actions using resources, and the basic units of the action
8	resource	the general designation of all kinds of resources used by the forces in the action
9	branch selection	according to the constraints, selecting the corresponding segment or action from a segment set or action set in which the branch relationships are mutually exclusive
10	command post	temporary agency established for the command of the operations and non-combat military operations
11	executive force	also called the object of command , referring to the general designation of the units and staff under direction in the commanding relationship
12	commander	staff who have been entrusted with and carry out the right of command

5.2. Category attribute

Category attribute can be determined according to the construction basis and the definition and concept of category of operational plan ontology model, as shown in figure 2. (abbreviation: Sg= segment, Ct= constraint, Ex= executive, Sup= superior, Cm= command, Cmdr= commander)

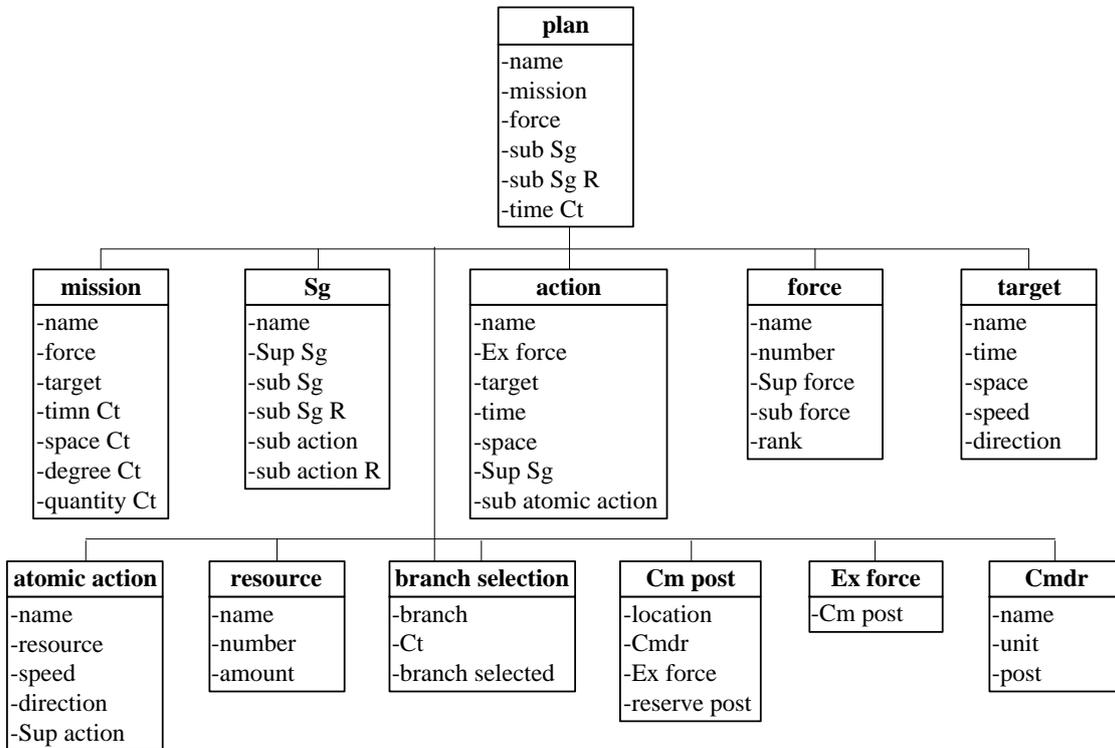


Figure 2. Category attribute of operational plan ontology model

5.3. Relationship

5.3.1. Definition of relationship. The relationship of operational plan ontology model can be defined using the following form:

$$R(C_1, C_2), \text{ or } R(C_1, A_1)$$

Wherein: R is relationship. C₁ is associated with C₂, or A₁ with the way R. C₁ is category, and C₂ or A₁ is either category or attribute.

5.3.2. Relationship description. There are 19 types of relationships between operational plan ontology models, and each type of relationship consists of several specific relationships, with a total number of 74. These relationships are classified as general relationship and special relationship according to the degree of combination with domain knowledge. There are 10 types of general relationships, which are attribute, parent-child, decomposition/aggregation, selection, serial, parallel, mutually exclusive, subordinate/superior, ownership, and constraint relationship. There are 9 types of special relationships, which are completion, execution, targeting, undertaking, in (space), at(time), interaction, usage and command relationship.

Figure 3 describes the relationships of all the 14 composition categories with conceptual graph. The relationships between categories form a complicated direct network [11], in which the relationships of the operational action categories, involving 8 types, are the most complex. The relationships of the categories are obviously a knowledge network with operational action as its core. The complexity of relationships of operational forces category comes next, involving 5 types. (abbreviation: decomposition/aggregation= De/Ag)

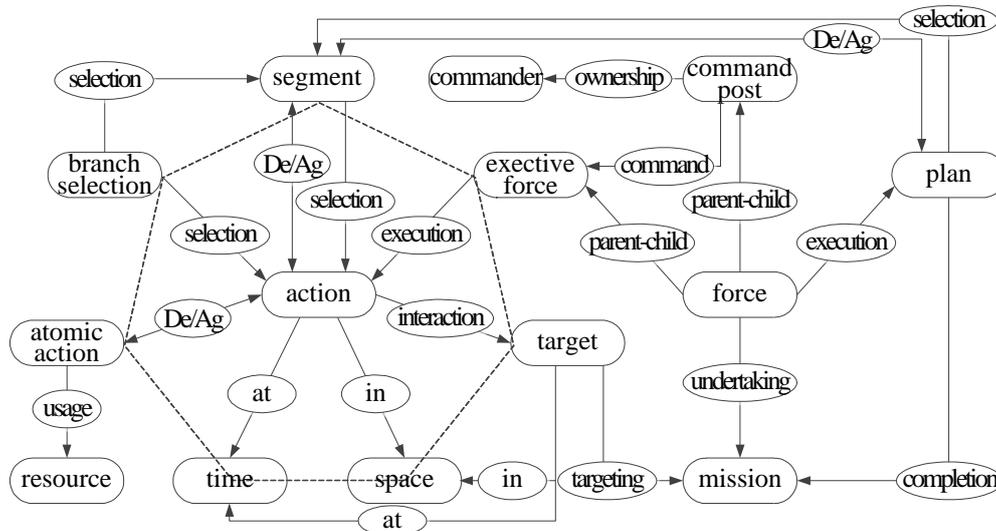


Figure 3. Relationships among the operational plan ontology model categories

Due to space limitation, only the main specific relationships are given below. Table 2 and 3 are the decomposition/aggregation and constraint relationships respectively belonging to general relationship. Table 4 and 5 are the execution and interaction relationship respectively belonging to specific relationship.

Table 2. Decomposition/aggregation relationships

No.	R (C ₁ , C ₂), or R (C ₁ , A)
1	De/Ag (plan, sub segment)
2	De/Ag (sibling segment, sub segment)
3	De/Ag (sibling segment, sub action)
4	De/Ag (sibling action, sub atomic action)
5	De/Ag (sibling Ex force, sub Ex force)

Table 4. Execution relationships

No.	R (C ₁ , C ₂), or R (C ₁ , A)
1	Execution (force, plan)
2	Execution (Ex force, action)

Table 3. Constraint relationships

No.	R (C ₁ , C ₂), or R (C ₁ , A)
1	Constraint (time constraint, plan)
2	Constraint (space constraint, plan)
3	Constraint (degree constraint, mission)
4	Constraint (condition, branch selection)

Table 5. Interaction relationships

No.	R (C ₁ , C ₂), or R (C ₁ , A)
1	Strike (action, target)
2	Seize (action, target)
3	Defense (action, target)

6. Application of operational plan ontology model

The core application of operational plan ontology model is the expression of operational plan. First, the basic applications, which is to describe specific operational plan completely with the model independently. Second, advanced applications, which is to develop the application software to realize the basic applications and other more advanced extensions.

6.1. Expression of the operational plan based on the ontology model

By using the category, category attribute and relation of the operational plan ontology model, specific operational plans can be described according to the process in a unified and standardized way. The steps are as follows: The first step is building the tree of the operational forces. The second step is building the tree of the operational actions, which is the core work. The third step is expressing other elements, such as operational plan, operational mission, operational target, and commander, etc..

6.2. Application software of the operational plan ontology model

The operational plan ontology model can really play the value only through the development of application software. In the assistant decision-making system, the application software is in an important position, so it is called the core layer. It is closely related to the application layer and user layer. Application layer refers to the operational plan software modules in different professional fields. User layer refers to the human-computer interaction part of the assistant decision-making system. The localization and application method of application software is shown in figure 4.

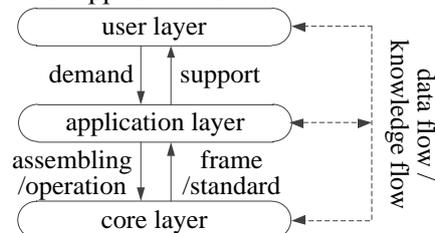


Figure 4. Localization and application method of application software

7. Conclusion

Faced with the interconnection and interoperability of operational plan among assistant decision-making systems, ontology technology has significant advantages. The article focuses on the theoretical exploration of the construction of the semi-knowledge-level operational plan ontology model, and opens up a new solution to the bottleneck problems. To actively promote the application of the results of the research, follow-up study in two aspects needs to be carried out: First, constantly improve and perfect the operational plan ontology model through demonstration and trial projects. Second, the application of operational plan ontology model, especially the design and development of software. To realize the core value of the ontology model and promote the leapfrog development of the equipment with assistant decision-making system.

8. References

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Acknowledgments

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