Construction and Application of the Operational Plan Ontology Model

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***Abstract*—Aiming at the bottleneck of assistant decision-making system caused by traditional expression method of the operational plan, this paper introduced the ontology technology in the information system field, and analyzed the advantages of the operational plan ontology model. On the basis of the determination of the components of the model, it constructed the operational plan ontology model for interconnection and interoperability. The function, level and mechanism of the application software of the model were also discussed in this paper. Thus, it has great guiding significance and practical value for the improvement of interconnection and interoperability of the assistant decision-making systems.**

Keywords-operational plan; expression method; ontology model; ontology application; assistant decision-making system

I. INTRODUCTION

With the rapid development of system operation based on information system, the demand for sharing and exchanging the data and knowledge of the operational plan among assistant decision-making systems is increasing[1]. The present technique system of the operational plan expression is mainly "fixed description templates + static data specification" [2-3]. This technique system has many problems, such as large deviations, poor description validity, and format conversion difficulty, etc., which seriously impede the interconnection and interoperability among systems, and constrain the improvement of the overall capacity of system operation. There is a pressing need for new effective technique system, while ontology technology has been proved effective in solving similar problems in commercial information systems[4]. Therefore, this paper introduces the ontology technology and probes into the operational plan ontology model and its application applicable to assistant decision-making systems. This paper aims at contributing to the solution of the bottleneck problems which constrain the interconnection and interoperability among the assistant decision-making systems.

II. ADVANTAGES OF THE OPERATIONAL PLAN ONTOLOGY MODEL

A. Significance

In the operational plan expression, the operational plan ontology model, which is the meta-model, plays a dual role. First, it regulates the elements and relationships of the operational plan, so as to guarantee the consistency of operational plan description among assistant decision-making systems. Second, it provides a unified framework of the operational plan model, which guides the construction of operational plan models of various fields.

B. Problems that Can be Solved

The following problems can be solved by the usage of ontology model: First, operational plan models are constructed flexibly, to meet the need of varied practical description. Second, operational plan elements are unified[5], to ensure the interconnection and interoperability among heterogeneous systems. Third, the ontology model is the standard in both newly developed and existing systems, to increase the reliability of format conversion of heterogeneous operational plans, and reduce the workload.

III. COMPOSITION OF THE OPERATIONAL PLAN ONTOLOGY MODEL

A. Definition of the Elements

The operational plan ontology model is composed of five elements of the operational plan knowledge: category, category attribute, relationship, axiom and instance[6], as shown in Table I.

$$Onto\_plan=<C, A, R, X, I>$$

TABLE I. ELEMENTS OF THE OPERATIONAL PLAN ONTOLOGY MODEL

Name	Explanation
C	a set of objects with similar features, describing the important concepts of the plan knowledge
A	a set of properties of the category, describing the inner structure of the plan ontology model category; one category can be the attribute of another category
R	the interrelation between categories(category and attribute), describing the interaction between the categories(categories and attributes) of the plan ontology model
X	the statement of permanent validity, describing the valid assertion in any case in the plan knowledge
I	the concrete objects corresponding to the categories, describing the specific elements of the plan knowledge

B. Level Analysis of the Elements

The elements of the operational plan ontology model can be divided into two levels: First, data level. Category: all the categories necessary for the expressions are included. Category attribute: the requirement of data exchanging is fulfilled. Instance: all the elements necessary for the descriptions are included. Second, higher knowledge level. Relationship: All the relationships among the various elements are included. Axiom: The inspection and judgment rules and operation rules in various fields are included[7].

IV. CONSTRUCTION OF THE OPERATIONAL PLAN ONTOLOGY MODEL

According to the definition and level analysis of elements, the operational plan ontology model for interconnection and interoperability, at a semi-knowledge level, includes three elements—category, attribute and relationship, which will be the focus of the following construction[8].Targeted research on axiom and instance can be conducted according to the application demand.

A. Categories of the Operational Plan Ontology Model

According to the structure and importance[9], the categories of the operational plan ontology model are classified as core categories and subordinate categories, which are 7 and 6, respectively, as shown in Figure I, where the arrows indicate the subordinate relationships among the categories.

B. Category Attributes of the Operational Plan Ontology Model

Category attributes can be determined according to the expression demand of the operational plan and the definition and connotation of the ontology model categories. Among them, the time and space belong to the general category, and the category attributes are based on relative references[10-11]. Category attributes of the operational plan ontology model are shown in Figure II. (abbreviation: Sg= segment, Ct= constraint, Ex= executive, Cm= command, Cmdr= commander)

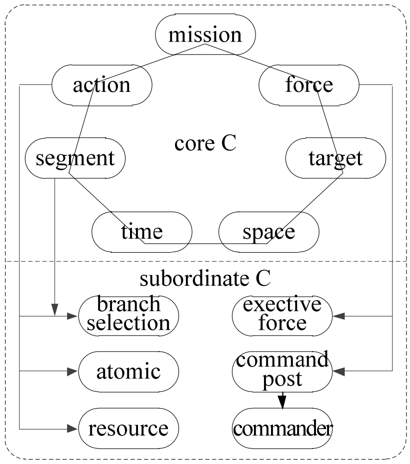

FIGURE I. CATEGORIES OF THE OPERATIONAL PLAN ONTOLOGY MODEL

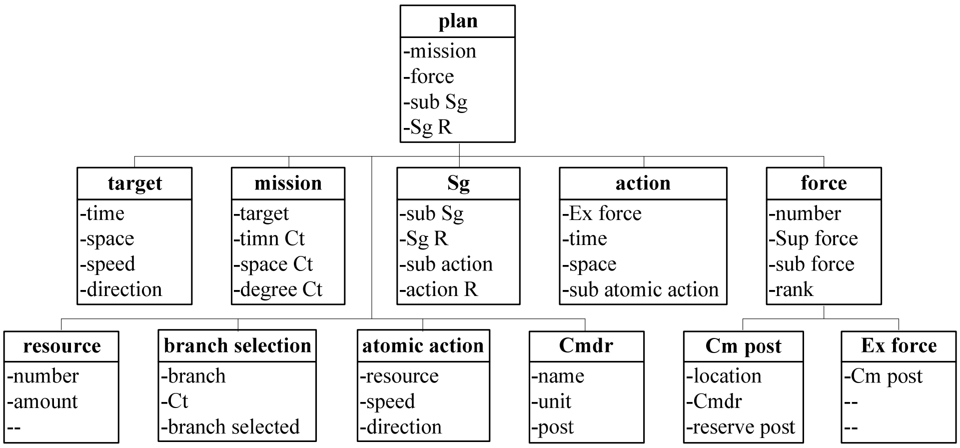

FIGURE II. CATEGORY ATTRIBUTES OF THE OPERATIONAL PLAN ONTOLOGY MODEL

C. Relationships of the Operational Plan Ontology Model

1) Relationship classification: The relationships of the operational plan ontology model are classified as general relationships and special relationships according to the degree of combination of the same-domain knowledge.

First, general relationships. There are 10 types of relationships, which are decomposition/ aggregation, attribute, parent-child, selection, serial, parallel, mutually exclusive, subordinate/ superior, ownership, and constraint relationships.

Second, special relationships. There are 9 types of relationships, which are completion, execution, targeting, undertaking, in (space), at (time), interaction, usage and command relationships.

Each of these major categories of relationships above can be subdivided into several minor categories, with a total number of 74.

2) Relationship expression: The relationships of the operational plan ontology model can be expressed in the form of figure and table. Due to space limitation, only the main relationships are given below. The relationship figure is a complicated directed network. The relationship figure of the operational action categories, involving 8 types, is the most complex. The complexity of the relationship figure of the operational forces categories comes next, involving 6 types. Figure III and IV describe these two relationships respectively with concept map method. (abbreviation: decomposition/ aggregation= De/Ag)

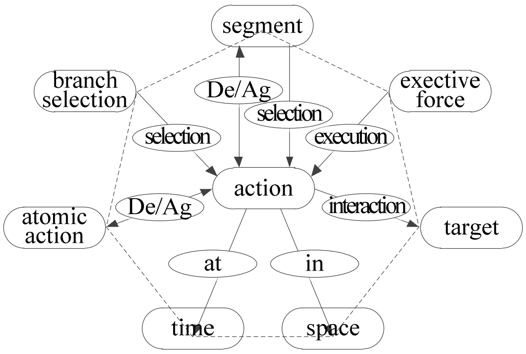

FIGURE III. RELATIONSHIP FIGURE OF THE OPERATIONAL ACTION CATEGORIES

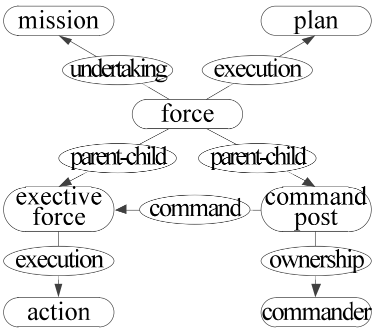

FIGURE IV. RELATIONSHIP FIGURE OF THE OPERATIONAL FORCES CATEGORIES

Table II and III respectively present the parent-child and selection relationship belonging to the general relationship[12]. Table IV and V respectively present the in (space) and at (time) relationship in the special relationship. Wherein: R is relationship. C_1 is associated with C_2, or A_1 with the way R. C_1 and C_2 are categories, A_1 is attribute.

TABLE II. PARENT-CHILD RELATIONSHIPS

No.	R (C_1, C_2), or R (C_1, A_1)
1	Parent-child (target, effective strength)
2	Parent-child (target, armament)
3	Parent-child (target, installation)
4	Parent-child (target, other targets)
5	Parent-child (resource, armament)
6	Parent-child (resource, information)
7	Parent-child (resource, logistics)
8	Parent-child (resource, command post)
9	Parent-child (resource, executive force)

TABLE III. SELECTION RELATIONSHIPS

No.	R (C_1, C_2), or R (C_1, A_1)
1	Selection (branch selection, selected branch)
2	Selection (plan, sub Sg)
3	Selection (sibling Sg, sub Sg)
4	Selection (sibling Sg, sub action)

TABLE IV. IN (SPACE) RELATIONSHIPS

No.	R (C_1, C_2), or R (C_1, A_1)
1	In (target, space)
2	In (action, space)
3	In (command post, location)

TABLE V. AT (TIME) RELATIONSHIPS

No.	R (C_1, C_2), or R (C_1, A_1)
1	At (target, time)
2	At (action, time)

V. APPLICATION OF THE OPERATIONAL PLAN ONTOLOGY MODEL

The application objective of the operational plan ontology model is to express the operational plan. But the ontology model can exert top-level guidance only at the flexible theoretical basis layer. The ultimate demand of interconnection and interoperability cannot be fully guaranteed. The application software development that is at the rigid tangible-product layer, can be applied to engineering practice directly, which can maximize the function of the operational plan ontology model, thereby guaranteeing the effectiveness of interconnection and interoperability among assistant decision-making systems.

A. Main Function

The application software of the operational plan ontology model consists of two levels: basic function and extended function. First, basic function. Based on the model-form operational plan expression, the software-form operational plan expression is realized correspondingly, namely describing the specific operational plan completely with elements like categories, category attributes, relationships, etc. in the software form. Second, extended function. On the basis of the basic function, different extent and scale extensions, from data level to knowledge level (such as the basic operational plan editing and processing function, data support function, etc. and advanced operational plan logic check function, intelligent reasoning function, etc.), can be conducted according to the application demand.

B. Application Level

According to the depth and breadth of application, the application of the application software of the operational plan ontology model in the assistant decision-making systems can be divided into 3 levels: primary, intermediate and advanced level, as shown in Table VI.

TABLE VI. APPLICATION LEVELS OF THE APPLICATION SOFTWARE

No.	Level	Application style	Object
1	primary	data format transformation	underlying database
2	intermediate	application tools modification	application layer tools
3	advanced	new design development	application layer tools user layer interface

C. Application Mechanism

The application software is at the core layer in the assistant decision-making system. It is closely related to the application layer and user layer. Application layer refers to the operational plan software modules in various professional fields. User layer refers to the human-computer interaction part of the assistant decision-making system. Figure V is the application mechanism of the application software, which plays the significant dual role. First, the core layer provides the framework and standard for the application layer. Second, the application layer assembles and operates the elements and data of the core layer. In addition, the user layer makes requirements to the application layer, which supports the user level.

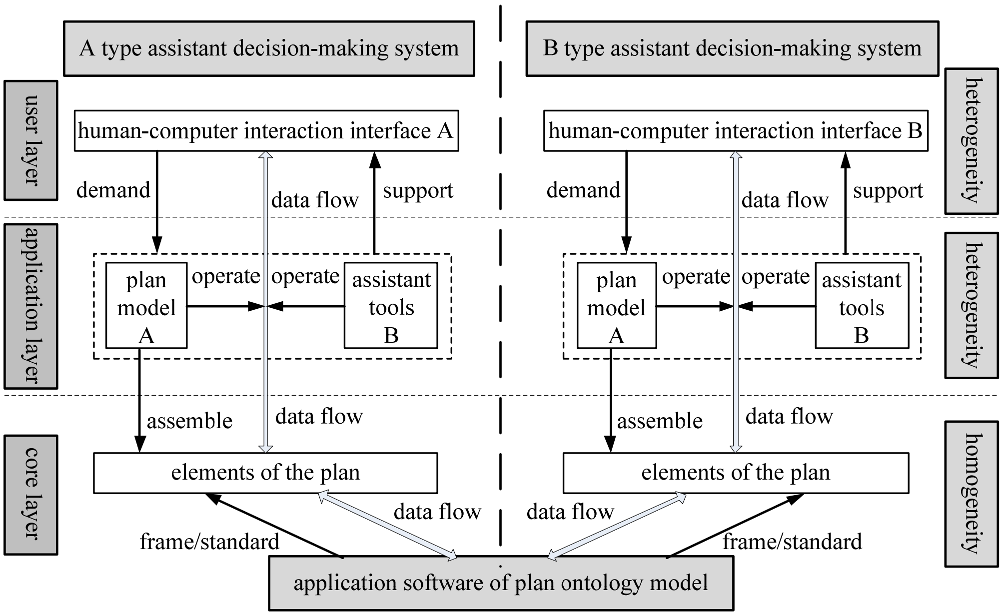

FIGURE V. APPLICATION MECHANISM OF THE APPLICATION SOFTWARE

VI. CONCLUSIONS

Aiming at the bottleneck of the traditional expression method of the operational plan, this paper puts forward a new technology system thought based on the ontology model, constructs the core operational plan ontology model, and carries out an initial investigation into the actual application. The new technology system can effectively deal with the demand of interconnection and interoperability among the assistant decision-making systems. In order to accelerate the application of equipment engineering, a lot of research work, such as the improvement and perfection of the ontology model, the design and development of the application software, and user's guide and trial, etc. should be carried out.

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