Tactic of Military Knowledge Interconnection Based on Semantic

Liquan Han
College of Computer Science and Technology, Jilin University ChangChun, P.R. China
College of Computer Science and Engineering, Changchun University of Technology ChangChun, P.R. China
Email: asehan@163.com

Shufen Liu and Zhengxuan Wang
College of Computer Science and Technology, Jilin University ChangChun, P.R. China
Email: liusf@jlu.edu.cn

Abstract—**The paper introduce a concept analysis method based on ontology, and applied to the construction of military knowledge. Using the method we establish an ontological structure and concept between the military knowledge and communication, in order to eliminate differences between military knowledge. The conceptual analysis of knowledge can be constructed to the knowledge operability can be realized and knowledge refinement can be achieved. Moreover, the contradictive and redundant knowledge can be found. Knowledge interconnectivity also can check consistency and completeness of knowledge base. According to the characteristics of the military domain knowledge and semantic interoperability methods. The paper puts forward Semantic Tree and Relation Degree, and description logic is given with the mapping ontology language. Finally completed the analysis of the military concept of domain knowledge and reasoning process, also provides the corresponding algorithm.**

Index Terms—**military knowledge interconnection; semantic tree; knowledge ontology; smart transcript; relation degree measure**

I. INTRODUCTION

Knowledge management is the hottest subject of the day. Knowledge Engineering was set up as a new discipline in Artificial Intelligence with the objective of providing methods and tools for constructing knowledge-based systems in a systematic and controllable way[1]. China National Knowledge Infrastructure (CNKI) is a key national e-publishing project of China started in 1996. CNKI is a symbol of Chinese e-publishing industry, which greatly boosted the Chinese library systems to go digital and helped researchers with their work.. Military knowledge base will be a subset of CNKI.

The military domain knowledge is a vast and complex system of knowledge, there are many different knowledge sources. Military knowledge management is activity of military knowledge and military resources and related processes to manage concepts, its purpose is to promote the sharing of military knowledge and innovation, and promote the rational use of military knowledge resources and optimize the configuration. Foreign troops is studying the Ideas and methods of knowledge management in applications. High Performance Knowledge Bases (HPKB) is a large military project with founded of support by DARPA of America in recent years, and has been the concern of western powerful nations. An ontology is a formal, explicit specification of a shared conceptualization[2]. Depending on their level of generality, different types of ontologies may be identified that fulfill different roles in the process of building a knowledge-based system[3]. Ontology has become a popular research topic and have been investigated by several Artificial Intelligence Research communities, including Knowledge Engineering, natural-language processing and knowledge representation.

Based on the concept of military knowledge and the relationship between the concepts, the paper puts forward the concept of military knowledge domain ontology, and builds the connection between the concepts to solve some questions, such as the inconsistencies in the concept, the disagreement in granularity, deepness and extent. The relation of military knowledge can be associated with the same knowledge in classification not only to increase the interpretation of the meaning of military knowledge, but also to judge the correctness of the knowledge, consistency, simplicity and integrity.

The paper is organized as follows. Section 2 introduces the architecture planning in the semantic analysis. Section 3 mainly describes the definitions of military ontology design and semantic interoperability. Section 4 describes the semantic interconnection of military knowledge, the Arithmetic and the measure of interconnection intensity. Conclusions and with future applications are given in Section 5.

II. SEMANTIC ANALYSIS ARCHITECTURE PLANNING

A. Framework of Military Knowledge

Knowledge Ontology, as a modeling tools of describing on a conceptual model of information system in semantic and knowledge levels, meets the garget to obtain, describe and express the knowledge of related

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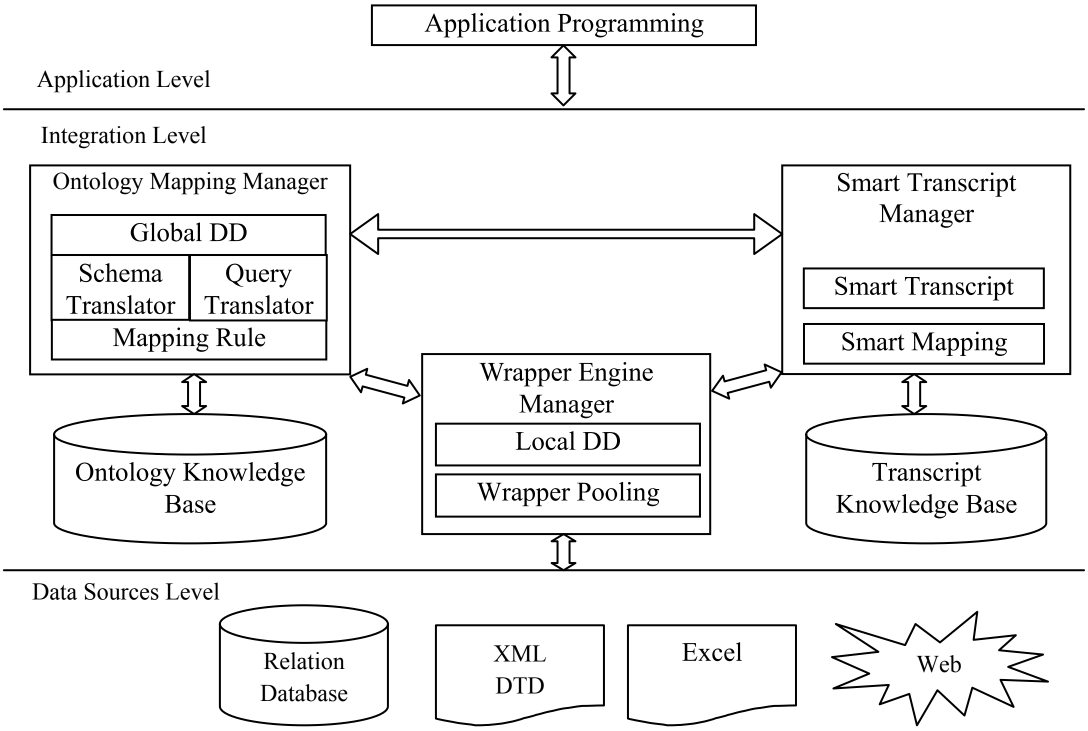

Fig.1. The Framework of visual model from Heterogeneous Data Sources

fields. Knowledge Ontology can provide a common understanding of knowledge and determine the recognition vocabulary in the fields. Knowledge Ontology also can give unambiguous definitions of the relationship between vocabulary in formal models from different levels of these terms. Knowledge Ontology expresses semantics with an explicit and formal way to improve interoperability between of the military concept and promote knowledge sharing. The method that is approved in this paper supports two mechanisms for data integration, i.e., the materialized view and the virtual view. The former keeps data of the involved sources for answering queries, while the latter keeps a view over the sources. The particular architecture included three level: application level, integration level and data sources level in Figure 1.

(1) Application Level: This level offers to a interface to users who using the functions in integration level through the application programs. The framework supports an uniform workspace to query and select.

(2) Integration Level: it is the center of the framework. This level shields the data distributing and heterogeneous, and view the data as local. There are two simple interfaces to link between application level and data sources level. Ontology Mapping Manager, Smart Transcript Manager and Wrapper Engine Manager, which are supported by Ontology Knowledge and Transcript knowledge Base, are important part in this level.

Ontology Mapping Manager: Ontologies are one way to represent explicit, formal semantics. An ontology is “an explicit specification of a conceptualization”[2]. In this approach, ontologies can be applied to ensure semantic interoperability between data sources. By using ontologies, the semantics of data provided by data sources for integration can be made explicit with respect to an ontology a particular user group commits to. Based on this shared understanding, the danger of semantic heterogeneity can be reduced. Note that to avoid problems similar to single global schemas, no single global ontology should be predetermined for all possible user groups. Such an approach would force users to adapt to one single conceptualization of the world. Therefore, a proper approach to data integration should support different ontologies so that different community-specific semantics can be used in parallel.

Wrapper Engine Manager: To the heterogeneous data, wrapper engine is a translation engine to the relation schema. Adapt to multi- heterogeneous data sources, our approach firstly put forward the Wrapper Pooling conceptual that is managed through wrapper engine manager and able to link with all kinds of data sources. Data from heterogeneous sources is often integrated by defining one single global schema that represents a unified view over this data. Global schema approaches can be classified as follows:

(a) Traditional Global Schema Approaches These approaches use a data model that originates from the era before object-orientation, such as the functional or relational data model, to provide one single global schema for all users. As in Multibase and Mermaid, export schemas from the data sources are directly mapped to the global schema.

(b) Object-Oriented Global Schema Approaches Data sources provide interfaces which can be used to define a global schema using an object-oriented data model. These approaches generally employ integration by creating superclasses to subsume related data from several data sources.

(c) Single Domain Model/Ontology Approaches These approaches use a single domain model or ontology against which all data is integrated, e.g., as in SIMS, Carnot and PICSEL[4]. A “semantic” approach to integration is chosen by integrating against one general domain model.

Smart Transcript Manager: it is responsible for generating and maintaining “Smart Transcripts”. Transcripts are not necessary “scripts”. They can be database entries as well. Transcripts are used to “record” information about the activity of the wrapper engine manager composition, such as states, action items, important milestones, etc.. Transcripts could be used to make references to past events. All past translation composition documents and files are stored in the transcript knowledge base. The transcript management module is responsible for managing the transcript, including: Build the transcript files; Store the transcript files into database; Export the transcript from database.

(3) **Data Sources Level:** is made up distributing and heterogeneous data sources, which is a relation database (such as SQL SERVER, ORACLE etc.) or semi-structured document (such as XML) or Web data. For the type of data to be integrated in our approach, we focus on alphanumeric data. Other types of data, such as images, audio and video data, or binary data files are only considered as atomic files with no additional internal structure.

B. Description Logics Mapping

Description Logics are responsible for many of the cornerstone notions used in knowledge representation and reasoning. They helped crystallize many of the ideas treated informally in earlier notations, such as concepts and roles[5]. Military Knowledge bases based on Description Logics provides facilities to set up, to reason about their content, and to manipulate them. An architecture of such a theory is in Figure 2.

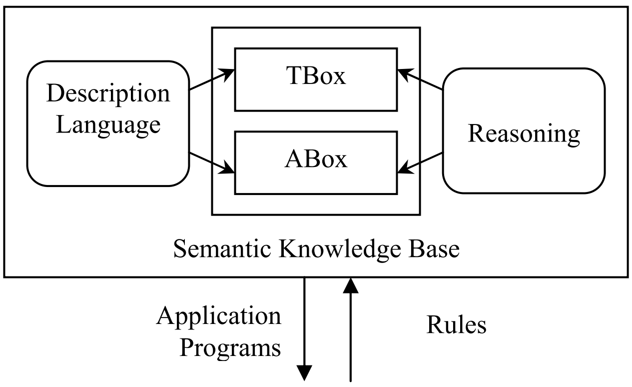

Fig. 2. knowledge representation based on DL

A semantic knowledge base (SKB) comprised two components, the TBox and the ABox. The TBox introduces the terminology, i.e., the vocabulary of an application domain ontology, while the Abox contains assertions about named individuals in terms of this vocabulary. The vocabulary consists of concepts, which denote sets of individuals, and roles, which denote binary relationships between individuals. In addition to atomic concepts and roles (concept and role names), all DL systems allow their users to build complex descriptions of concepts and roles. The TBox can be used to assign names to complex descriptions. The language for building descriptions is a characteristic of each DL system, and different systems are distinguished by their description languages. The description language has a model-theoretic semantics. Thus, statements in the TBox and in the ABox can be identified with formulae in first-order logic or, in some cases, a slight extension of it[5].

Description Logics introduces syntax and semantics, covering the basic constructors that are used in systems or have been introduced in the literature, and the way these constructors can be used to build knowledge bases. The semantic is a interpretation as $I = (\Delta', \bullet')$, where $\Delta'(\Delta' \neq \varnothing)$ is a interpretation domain. Description Logics mapping with ontology is showed in Table 1.

Elementary descriptions are atomic concepts and atomic roles. Complex descriptions can be built from them inductively with concept constructors.

TABLE 1.

DESCRIPTION LOGICS MAPPING WITH ONTOLOGY

Symbolic names	Ontology Semantics
T	$T' = \Delta'$
$\perp$	$\perp' = \Phi$
$\neg C$	$(\neg C)' = \Delta' \setminus C'$
$D \cap E$	$(D \cap E)' = D' \cap E'$
$\forall P.D$	$(\forall P.D)' = \{a \in \Delta' \mid \forall b.(a,b) \in P' \rightarrow b \in D'\}$
$\exists P.T$	$(\exists P.T)' = \{a \in \Delta' \mid \exists b.(a,b) \in P'\}$
$D \cup E$	$(D \cup E)' = D' \cup E'$
$\exists P.D$	$(\exists P.D)' = \{a \in \Delta' \mid \exists b.(a,b) \in P' \wedge b \in D'\}$
$\leq nP$	$(\leq nP)' = \{a \in \Delta' \mid \{b \mid (a,b) \in P'\} \leq n\}$
$= nP$	$(= nP)' = \{a \in \Delta' \mid \{b \mid (a,b) \in P'\} = n\}$
$\geq nP$	$(\geq nP)' = \{a \in \Delta' \mid \{b \mid (a,b) \in P'\} \geq n\}$

III. MILITARY ONTOLOGY DESIGN AND SEMANTIC INTEROPERABILITY

A. Military Knowledge Service-ontology Conceptual Model

The central task of service modeling on the basis of ontology is to establish shared collection of services vocabulary. Service ontology can be regarded as a simple description of service terms and their management. Services are categorized as atomic service, the services that are unable to decompose into more fine-grained, and composite service, the services that are combined through a number of services [6]. The composite service is formed by the atomic service, role and construct identifier, according to certain rules. In describing the military ontology language we refer to the CNKI ontology language[7]. CNKI language is a Frame Language, and it adopts the theory from Generic Frame Protocol[8].

Definition 1 (Ontology Model): Ontology model O is defined as: O=<T, H, X>

Where:

(1) T is the collection of terminology, and the term in T are referred as the atomic term, including atomic term C (Shortened form: atomic class) and atomic attribute term P (Shortened form: atomic attribute), represented as T=<C,P>. According to the value range, there are two kinds of the ontology attributes: class attributes and data attributes. Class attributes represent the relationship among classes and data attributes are used to present the attributes of class;

(2) H is the inherited relationship collection of term T, including class inheritance and attribute inheritance, namely the subClassOf and subPropertyOf;

(3) X are ontology rule set, or ontology constraint set, and can be formally expressed with First-Order Predicate Logic or Description Logic.

Definition 2 (Service-ontology Model): Service ontology model is a triple and referred as the service ontology. Service-ontology model S is defined as: *S=<E, O, R>*

Where:

(1) E is event or action;

(2) O is the ontology model referred by the service ontology;

(3) R is the description of rules. The relationship of E and O is a kind of reference. The basic ontology concept are illustrated in O.

Definition 3 (Concept Model): In the service ontology, if two concepts Ci and Cj, and if Ci is the equivalentClass of Cj, then Ci and Cj are semantic equivalent, noted as Ci≡Cj; if Ci is the subClassOf Cj, then Ci semantic includes Cj, noted as Ci⊇Cj.

Definition 4 (Semantic Similarity):semantic similarity of service ontology concepts is defined as:

$$S\left(C_i, C_j\right) = \frac{a}{d + a} \quad (1)$$

Where:

(1) a is an adjustable parameter;

(2) d is an integer.

For the convenience of computing, we set the rules: if Ci≡Cj, then d=0; if Ci⊇Cj or Cj⊇Ci, then d = 1. If the concept collection CA(CA1,CA2,…,CAm) and CB(CB1,CB2,…,CBn) are CA⊇CB, then the semantic similarity are expressed as:

$$S\left(CA, CB\right) = \frac{1}{n}\left[\sum_{j=1}^{n} \max_{i=1}^{m}\left(S\left(CA_i, CB_j\right)\right)\right] \quad (2)$$

B. Ontological Meta-model and Semantic Interoperability

Ontological meta-model combines the features of ontology and meta-model, and has different ways to create: One way is to use the ontology semantics identification / mapping technology, and achieve the semantic connection of the ontology and meta-model/model. So semantic relation is the ontology meta-model. Another is the use the meta-model of ontology language, such as OWL-S language, RDF, RDFs and so on. There should be pointed out that: ontology meta-model of different types may be differences in semantic interoperability. The paper that achieves the way of the concept similarity degree of ontology will be described using the ontology meta-model to create in the field of military, in this process, the logic frame of military domain knowledge(such as military knowledge description logic) is the groundwork of implementation of mutual information, but also comes down to the question of semantic interoperability.

Depending on the military of the different theoretical knowledge is well constructed different military domain ontology knowledge base. In the process of completion to understand the knowledge has amount of question of semantic interoperability. The significantly reduces the coupling degree between the semantic. Coupling way converts from self-owned static and fixation to dynamic alliance, different degrees of change in close coupling. The paper puts forward a plan for building ontology meta-model began to refer to the set of attributes created and authoritative set of attributes specific application requirements and establishing a local ontology, and those recorded in the appropriate knowledge base. Using the information of registered, knowledge and attributes can

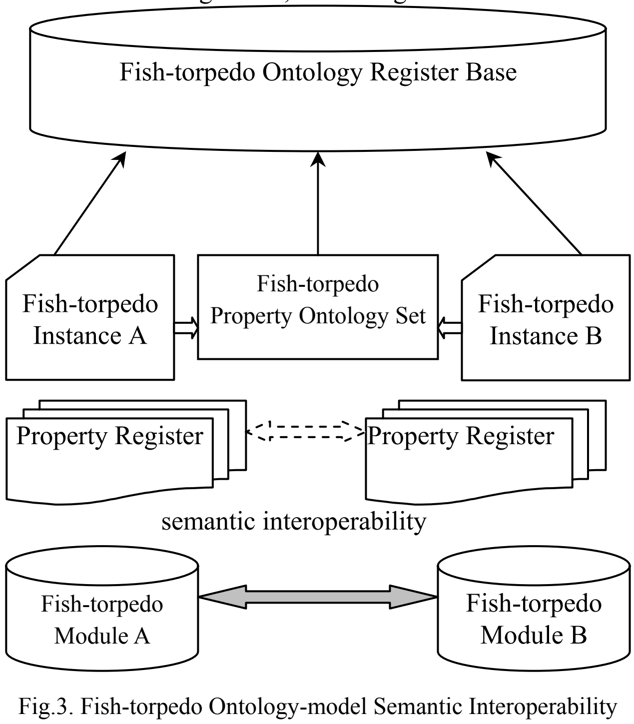

Fig.3. Fish-torpedo Ontology-model Semantic Interoperability

be created mappings between ontologies. Figure 3 shows the way of semantic interoperability based on the public reference ontology in the torpedo component library.

IV. SEMANTIC INTERCONNECTION OF MILITARY KNOWLEDGE

A. Semantic Tree of Conceptual Interconnection

The concept of military doctrine is more complex. Correctly understand the relationship between the concepts is the basis to people understanding military knowledge. At the same time, the concept of classification is the way of people organize knowledge, and solve the mapping process through the semantic interoperability between the concepts. More and more attention is to the ontology based on project. Semantic interconnection has been applied in varying degrees in many well-known knowledge system, such as the language knowledge base (WordNet[9]) by Princeton University and so on.

Concept can be expressed by relationship sequence. Idiographic format of relationship sequence is defined as: C1, R1, C2, R2,……, Cn, Rn，where, C1, C2, ……, Cn is concepts，R1, R2,……, Rn is relations。In order to better describe the relationship between concepts of military theory, we designed a Semantic Tree to express the classification system of the military knowledge. Here, we agree: Semantic Tree's root node has no practical significance for the high abstract structure.

Definition 5 (Semantic Tree): Semantic Tree is a connected undirected graph no consist of circle. The edge of semantic tree is called branch, the node of degree one is called leaf. Semantic Tree meet the following conditions: The leaf concept node is a instantiation of his upper concept node. For the concept of non-leaf node C_1 and C_2, if $I(C_1) \subseteq I(C_2)$, so say C_1 is an integral part of C_2, written as: ST(C_1, C_2). Where *I* is an interpretation function, finish the mapping from first-order logic to domain. Semantic Tree also written as ST hierarchy and used by *H* $H \subset C \times (C \cup \{Root\})$.

From the definition, we can know that the upper level concept is more abstract than the lower level concept. Associated with the definition and nature of the relationship, we can get a conclusion that ST satisfy the following properties:

(1) ST relation is a Second-order relation;

(2) ST relation is a classified slot of frame;

(3) ST relation includes two object, one object is a material instance, or Subconcept; another object is a Superconcept to the first object;

(4) ST relationship is reflexive, antisymmetric, non-delivery relationship.

With Discrete Mathematics theory of the tree and graph, here is some related ST in the definition of the concept structures:

Definition 5: ST is a second-order relation to meet the relation of Semantic Tree, C1 and C2 is non-leaf node in ST, there is some concepts:

(1) Height: refers to the total number of layers of the hierarchy in ST, written as: Height(root);

(2) Path: refers to the sequence from C1 concept node to C2 concept node. The total number of concept is written as Path long. In the Path from C1 concept node to C2 concept node, the shortest Path is named of Shortest Path, written as: $|\, path(C_1, C_2) \,| = n$;

(3) Depth: refers to the Path Long of C node from ST ROOT to C node. The Height of the Subtree by C ROOT node is written as: height(C). All appearance: Height(root) = depth(C) + height(C);

Through the transformation between the concepts in ST nodes, we can get the relationship between knowledge. It will become the basis of studying the semantic links in the further.

Definition 6: ST is a second-order relation to meet the relation of Semantic Tree, C1 and C2 is non-leaf node in ST, there is some concepts in the process of transformation:

(1) Conceptual Generalization: refers to the process of transformation from lower level concept to upper level concept;

(2) Conceptual Specialization: refers to the process of transformation from upper level concept to lower level concept;

(3) Conceptual Normalization: refers to the process of transformation from different level concept to the same level concept, in order to make comparable. Obviously, Conceptual Normalization shorter path needed to illustrate the concept more similar, and vice versa, then the greater the distance between concepts, and its similarity to the worse. When the distance to a certain extent, the concept has basically no relationship between the concept.

Obviously, upper relation of concept includes the process of Conceptual Generalization, lower relation of concept includes the process of Conceptual Specialization. Where CG(C_1) is the result set of Conceptual Generalization in C_1 and CG(C_2) is the result set of Conceptual Generalization in C_2, if $CG(C_1) \cap CG(C_2) \neq \varnothing$, so C_1 and C_2 is Upper Relation; Where CS(C_1) is the result set of Conceptual Specialization in C_1 and CS(C_2) is the result set of Conceptual Specialization in C_2, if $CS(C_1) \cap CS(C_2) \neq \varnothing$, so C_1 and C_2 is Lower Relation;

Based "Encyclopedia of China - Military Research" the classification of planes and ships, combined with the above definition, give a specific concept in Figure 4 (part). The ST can also m layers above the structure and n layers under the structure.

B. Measure of Interconnection Intensity

Semantic Tree of concepts in military knowledge is shown in Figure 4. However, the figure can not understand the difference between the links between concepts. So, the paper presents a Measure of Interconnection Intensity is calculated, and this method is defined as: Relation Degree (RD). RD can be used to describe the relation degree between the two concepts. Here to do the following provisions: The greater the value of RD, then the relationship between these two concepts more closely; otherwise, then the relationship between these two concepts is a fuzzy relation. ST is a second-order relation to meet the relation of Semantic Tree, C1 and C2 is non-leaf node in ST, C1 and C2 of the RD is calculated as:

$$RD(C_1, C_2) = \begin{cases} 1 & C_1 = C_2 \\ 1 - L(P(C_1, C_2))/H & C_1 \neq C_2 \end{cases} \quad (3)$$

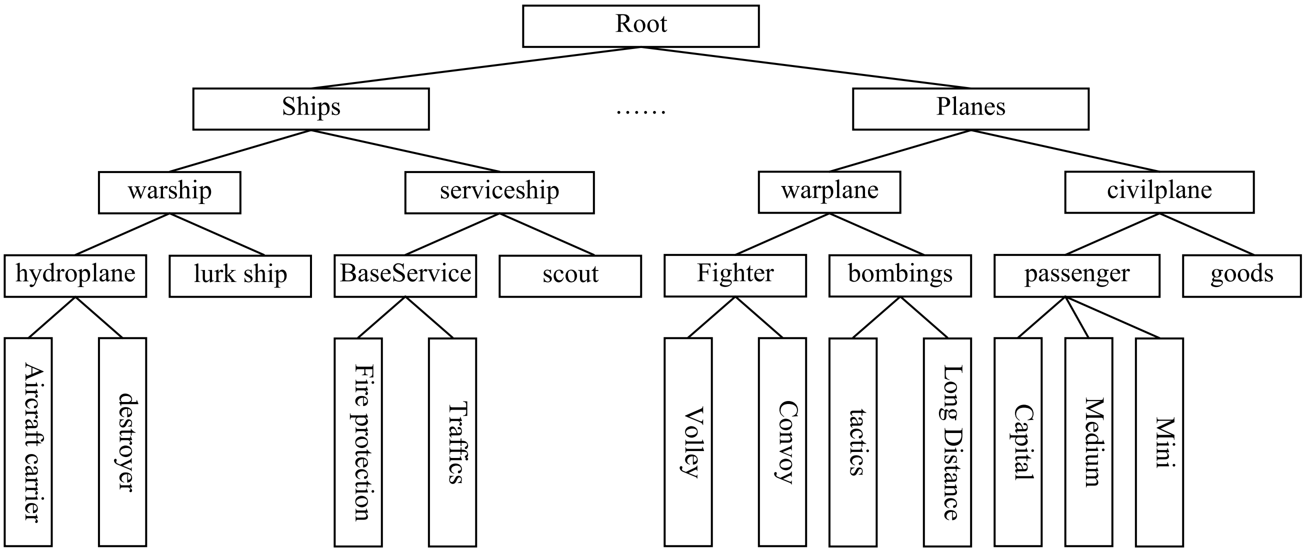

Fig.4. Semantic Tree of Military Knowledge (Ship and Plane Part)

Where,

P(C1, C2) is the parent node of C1 and C2, L(C) is the sum of total level of C node station, H is the HEIGHT of ST.

From the above formula, we can get the following properties:

(1) If RD(C1, C2) = 1, so C1 and C2 is same concept. Here that the concept is the same concept with different names, but refer to the same conceptual entity, the concept of entities, including the concept of short, another name, synonym, synonyms and so on. This is consistent with the definition of the concept of knowledge.

(2) If C1, C2 and C3 have the same patient node, so RD(C1, C2) = RD(C1, C3) = RD(C2, C3);

(3) RD(C1, C2) < RD(C3, C4); If the height of the common parent of C1 and C2 is higher then the height of the common parent of C3 and C4, then RD(C1, C2) < RD(C3, C4);

(4) If RD(C1, C2) = 0, then the common parent of C1 and C2 is ROOT node. At this time, there is no weight in ST of C1 and C2 concept.

(5) Relation Degree does not have a transitive. Where ID1 is the Relation Degree of C1 and C2, ID2 is the Relation Degree of C2 and C3, ID3 is the Relation Degree of C1 and C3, so ID3≠ID1 + ID2.

Combination with Figure 4, the paper gives a process of the concept of military knowledge:

If C1 is Aircraft carrier ship, C2 is Capital plane, so RD1(C1, C2) = 1 – L(P(C1, C2))/H = 1 – (5 + n)/H; if C2 is scout ship, so RD2(C1, C2) = 1 – L(P(C1, C2))/H = 1 – (4 + n)/H; Obviously:

ID1 < ID2

This shows that: the relation degree of Aircraft carrier ship and Capital plane is weaker than the relation degree of Aircraft carrier ship and scout ship. In fact, Aircraft carrier ship and scout ship belong to the ship in the context of the concept, they really should be larger relative degree, we can see, this result is consistent with the facts.

C. Arithmetic of Semantic Relation

After the above analysis, we know: the semantic tree of knowledge in the military process, the ultimate goal is to export as much as possible meaningful knowledge. To this end, we designed the following algorithm process:

Input: C1 and C2 are two concept of military knowledge;

Output: C1 and C2 on meaningful knowledge;

The algorithm process is:

step1: Based on the input type of Military knowledge organization, read knowledge base of knowledge, and the establishment of semantic tree;

step2: Traversal of the semantic tree using the method of traverse tree with middle, at the same time, data is processing;

step3: If C1 and C2 is straight concept relation in R， so output C1RC2 sequence，if C1 and C2 is straight concept relation in R’，so output C1R’C2 sequence;

step4: If C1 and C2 is transitive sequence in R*， where R have transitive，so output C1RC2 sequence，if C1 and C2 is transitive sequence in (R’)*, where R’ have transitive, so output C1R’C2 sequence;

step5: If C is a concept, at the same time, C1 and C is straight concept relation in R, C and C2 is straight concept in R’, if the second-order R’ cover the relation R, so output C1RC2 sequence; else if relation R cover the relation R’, so output C1RC2 sequence, else check the same result in C2 and C1 using the same way；

step6: According to the formula(3), the algorithm process calculate the relation degree and given the relationship between the sequence of degree with the output sequence.

D. Description Logics and Semantic Interconnection

It is a important task to combine the ST part of the military knowledge reasoning and mining after the establishment of ontology and knowledge base in the military. We can construct from the ST concept of military knowledge, reasoning, some knowledge of the unknown concept, you can also start from the concept known properties, reasoning unknown attribute knowledge.

Description Logics can provide good semantic reasoning ability and a strong tool that can meet the Semantic Relation of structure, integration and evolutionary processes, but also for Semantic Relation ontology reasoning is the ideal language. Identity has many analogies in conceptual modeling for databases, knowledge bases, object-oriented, and classical information systems, however none of them completely captures the notion[11]. The name description logics is motivated by the fact that, on the one hand, the important notions of the domain are described by concept descriptions, i.e., expressions that are built from atomic concepts (unary predicates) and atomic roles (binary predicates) using the concept and role constructors provided by the particular description logics[12].Concepts can be used to describe the relevant notions of an application domain. The terminology (TBox) introduces abbreviations (names) for complex concepts. The kind of assertions that may appear in the ABox. The set of constructs constituting the language used for building the concepts and the roles mentioned in the TBox and in the ABox. Our technique is optimal with respect to the complexity class of the inference problem, and has the same computational complexity (in the worst case) as the procedure for reasoning in a TBox expressed in the basic language ST.

V. CONCLUSIONS AND FUTURE WORK

Military knowledge management is associated activities of knowledge of military knowledge and military resources and related processes to manage things, its purpose is to promote the sharing of military knowledge and innovation, and promote the rational use of military knowledge resources and optimize the configuration. The paper discusses the method of concept analysis in military knowledge using the way of ontology, and put forward the Semantic Tree to express the information stored in military domain knowledge base. The semantic tree can link the two concepts through the attributes or attribute value of relation sequence. Measure of the relationship between the proposed algorithm is different from the degree of complete dependence MindNet weighted semantic path method. In the process , The special nature of military knowledge combined with the dynamic combination of military knowledge. The paper gives the process of reasoning using description logic. With this structure, developers allow to form the results of the study and implementation from the description logic systems.

The paper mainly studies the concept relation in knowledge relation. Knowledge relation alse includes the property relations, behavior relation and other relation. In the algorithm design process, the main consideration is semantics of knowledge, not taking about the pragmatic of knowledge. Using knowledge of the combination of semantic and pragmatic way, knowledge can be multi-faceted and deep-seated to describe, it will be a major aspect of future research.

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Liquan Han was born in Jilin Province, PRC in March 1973. He is studying to Doctor’s Degree in the College of Computer Science and Technology of Jilin University from 2005 to present.

He works as a Associate Professor in College of Computer Science and Engineering of Changchun University of Technology from 1996 to present. His active and diverse research interests include Semantic Web and ontology knowledge.

Shufen Liu was born in Jilin Province, PRC in July 1952. She is currently a Professor in the College of Computer Science and Technology of Jilin University. Her research activities have been focused on the Architecture of Software, Physical layer issues of network, Semantic Web and the technology of software building. She has published over 100 papers in journals and conferences.

Zhengxuan Wang was born in Jilin Province, PRC in July 1950. He is currently a Professor in the College of Computer Science and Technology of Jilin University. His research activities have been focused on the technology of image and ontology knowledge. He as published over 80 papers in journals and conferences.